FLUID MACHINES

Fluid power: it is designed specifically to perform work, accomplished by pressurized fluid bearing directly on an operating fluid cylinder or fluid motor.

Fluid cylinder produces force in linear direction while fluid motor produces torque in rotary motion.

Both cylinders and motors are called as **actuators**.

Fluid power is called **hydraulics** when fluid is liquid and is called **pneumatics** when the fluid is gas.

Hydraulic systems use liquids such as petroleum oil, synthetic oil and water. The first hydraulic fluid used was water, it has many deficiencies such as freezes readily, poor lubricant and tends to rust metal components.

There are two different types of fluid systems i.e. **fluid transport and fluid power**

Fluid transport: used to transport fluid from one location to another. E.g. pumping stations, cross country gas lines, chemical processing etc.

Advantages of fluid power

Power can be transmitted by three basic methods i.e. electrical, mechanical and fluid power. Most applications use combination of three methods to obtain efficienct overall system.

Fluid power can transmit power economically over greater distances than mechanical types but restricted to shorter distances than electrical systems.

Fluid power is versatile and manageable, it is not hindered by the geometry of machine as in case of mechanical system.

Advantages:

1) Ease and accuracy of control: By the use of simple levers and push buttons, operator can start, stop, speed up and slow down and position forces with very close tolerances.

2) Multiplication of force: A fluid power system (without using cumbersome gears, pulleys and levers) can multiply multiply forces from fraction of Newton to tons of output.

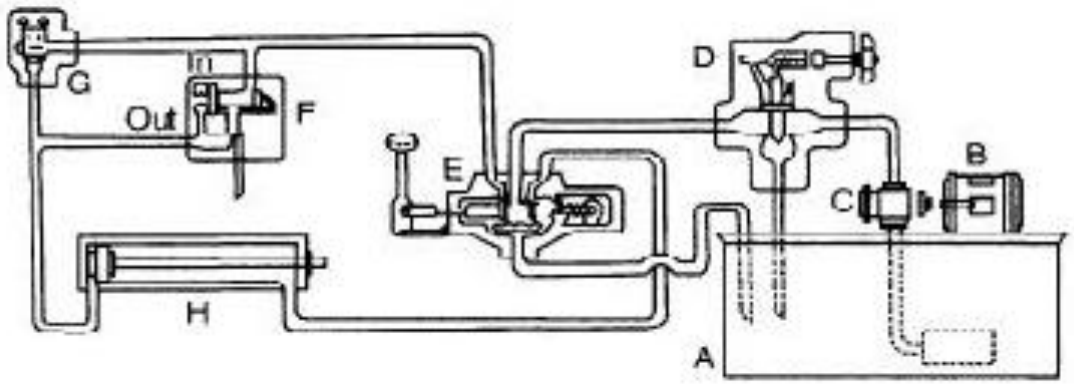
3) Constant force or torque: Only fluid power systems are capable of providing constant force or torque regardless of speed changes.

4) Simplicity, safety and economy: Use fewer moving parts, simpler to maintain and operate, therefore more safe, compact and reliable

Components of a fluid power system

Six basic components are required in hydraulic system

1. A Tank (Reservoir) to hold the hydraulic oil
2. A pump to force the oil through the system
3. An electric motor or other source to drive the pump
4. Valves to control oil direction, pressure and flow rate
5. An actuator to convert the pressure of the oil into mechanical force or torque to do useful work
6. Piping which carry oil from one location to other



List of components

A – Reservoir
B – Electrical motor
C – Pump
D – Maximum pressure (relief) valve
E – Directional valve
F – Flow control valve
G – Right-angle check valve
H – Cylinder

power transmission:

Hydro = water, aulos = pipe

The means of power transmission is a liquid (pneumatic → gas)

Hydrodynamic power transmission:

- Turbo pump and turbine
- Power transmission by kinetic energy of the fluid
- Still the relative spatial position is fixed
- Compact units

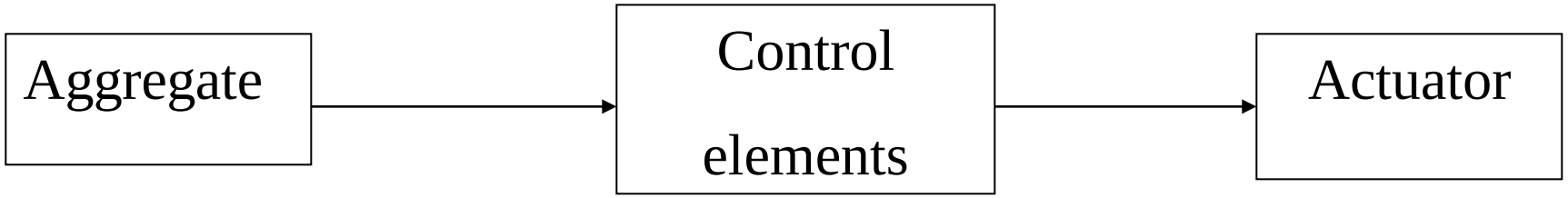
Hydrostatic power transmission:

- Positive displacement pump
- Creates high pressure and through a transmission line and control elements this pressure drives an actuator (linear or rotational)
- The relative spatial position is arbitrary but should not be very large because of losses (< 50 m)

A continuously variable transmission is possible

Most of this lecture will be about hydrostatic systems (in common language it is also called simply hydraulics)

Structure of a hydrostatic drive



Pump, motor

Fluid reservoir

Pressure relief valve

Filter

Piping

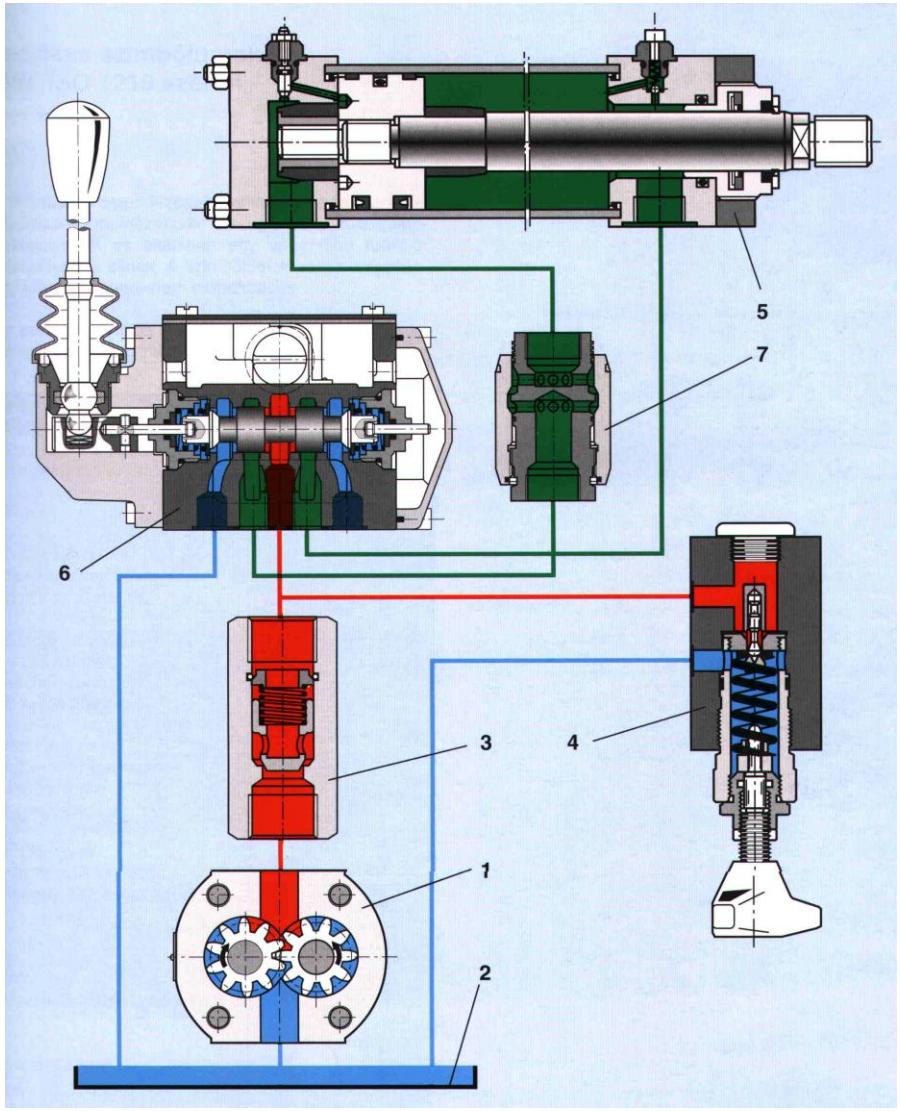
Valves, determining the path, pressure, flow rate of the working fluid

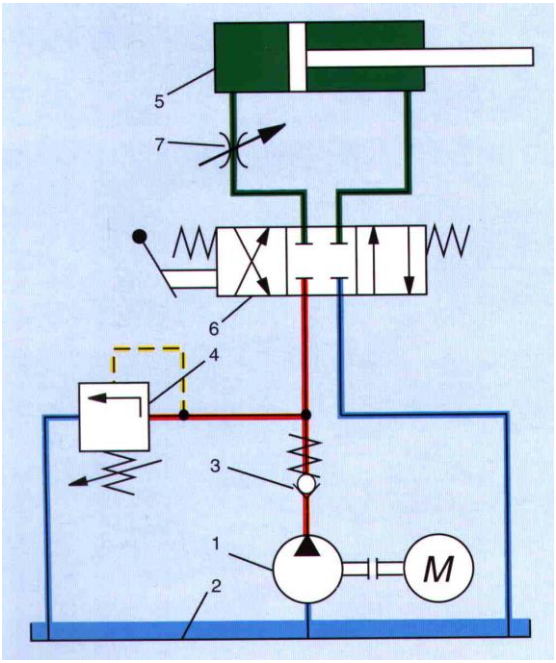
Elements doing work

- Linear
- Rotational
- Swinging

These components and their interaction is the subject of this semester

A typical hydraulic system





1 – pump
2 – oil tank
3 – flow control valve
4 – pressure relief valve
5 – hydraulic cylinder
6 – directional control valve
7 – throttle valve

Advantages of hydrostatic drives

- Simple method to create linear movements
- Creation of large forces and torques, high energy density
- Continuously variable movement of the actuator
- Simple turnaround of the direction of the movement, starting possible under full load from rest
- Low delay, small time constant because of low inertia
- Simple overload protection (no damage in case of overload)
- Simple monitoring of load by measuring pressure
- Arbitrary positioning of prime mover and actuator
- Large power density (relatively small mass for a given power compared to electrical and mechanical drives)
- Robust (insensitive against environmental influences)

Disadvantages of hydrostatic drives

- Working fluid is necessary (leakage problems, filtering, etc.)
- It is not economic for large distances

Module 1: Introduction to Hydraulics

All machines require some type of power source and a way of transmitting this power to the point of operation.

The three methods of transmitting power are:

- Mechanical
- Electrical
- Fluid

- In this course we are going to deal with the third type of power transmission which is the **Fluid Power**

Module 1: Introduction to Hydraulics

- **Fluid power** is the method of using pressurized fluid to transmit energy.

- **Liquid** or **Gas** is referred to as a **fluid.** Accordingly, there are two branches of fluid power; **Pneumatics,** and **Hydraulics**.

- **Hydraulic systems** use **liquid** to transfer force from one point to another.
- **Pneumatic systems** use **air** to transfer force from one point to another. Air is

Module 1: Introduction to Hydraulics

- **Air** is **Compressible:**

(*This describes whether it is possible to force an object into a smaller space than it normally occupies. For example, a sponge is compressible because it can be squeezed into a smaller size*).

- **liquid** is **Incompressible:**

(*The opposite to compressible. When a "squeezing" force is applied to an object, it does not change to a smaller size. Liquid, for example hydraulic fluid, possesses this physical property*).

Hydraulics

- **Hydraulics** is the study of pressure in liquids. Devices that transmit applied force through a liquid to move something else are called **hydraulic systems**.

Hydraulics

- In most hydraulic systems, a force is exerted on a continuous, enclosed liquid.

- This applied force creates pressure that moves the liquid through a series of tubes, pipes, or hoses, which causes a motion at the other end of a hydraulic system.

- Hydraulic systems are commonly used where mechanisms require large forces and precise control.

- Examples include vehicle power steering and brakes, hydraulic jacks and heavy earth moving machines.

- Hydraulics plays an important role in many industries; there are a lot of hydraulic applications in manufacturing, transportation, and construction sectors.

- Hydraulics systems are used where large, precise forces are required.

2.1 Common examples of hydraulic systems include:

2.1.1 Vehicle brake hydraulic systems

The function of a vehicle braking system is to stop or slow down a moving vehicle. When the brake pedal is pressed as illustrated in Fig. 1.1, the hydraulic pressure is transmitted to the piston in the brake caliper of the brakes. The pressure forces the brake pads against the brake rotor, which is rotating with the wheel. The friction between the brake pad and the rotor causes the wheel to slow down and then stop.

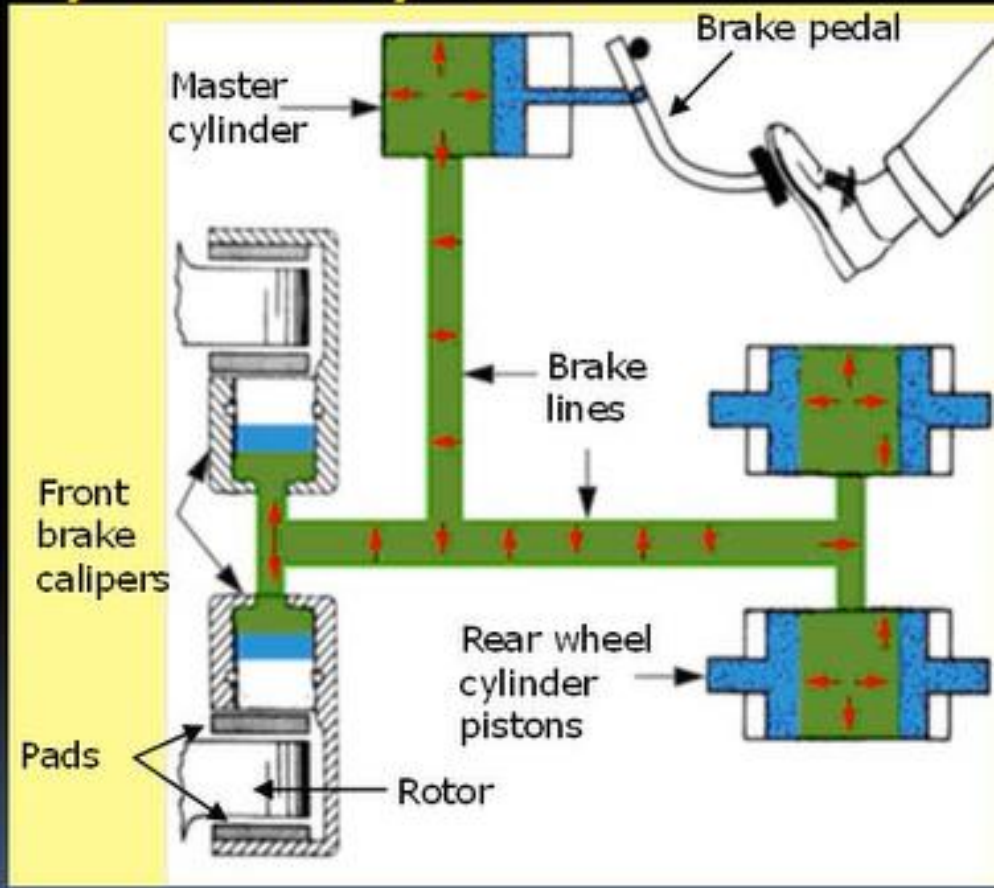


Fig.1.1: A schematic diagram of the vehicle's hydraulic brake system.

Tip: Watch the hydraulic brake

2.1 Common examples of hydraulic systems include:

2.1.2 Vehicle power steering

- The vehicle power steering system uses hydraulic oil, the hydraulic pump supplies the oil through the control valves to the power cylinder as shown in Fig. 1.2. The major advantage of using this system is to turn the vehicle's wheels with less effort.

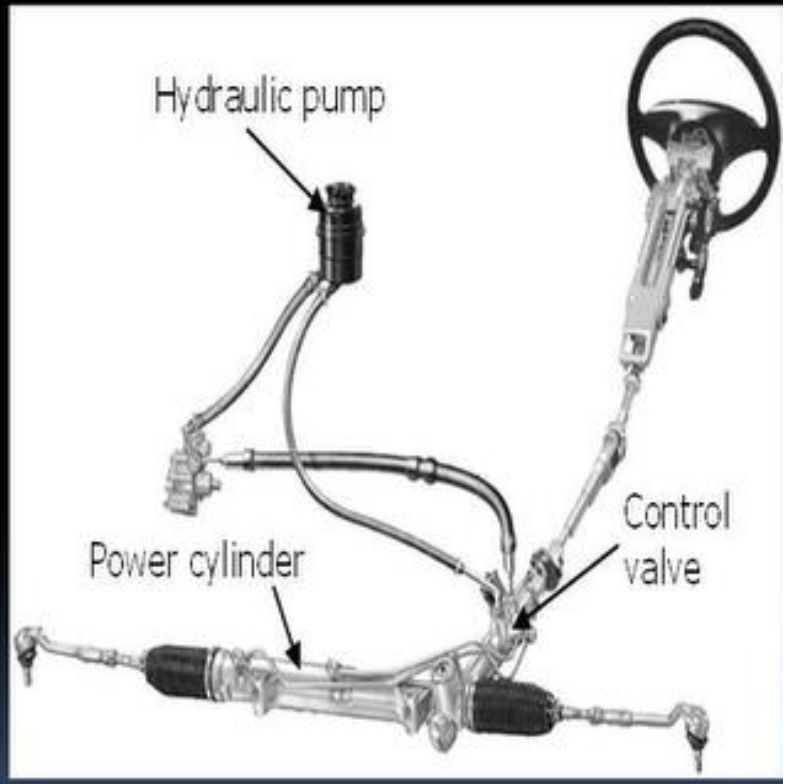


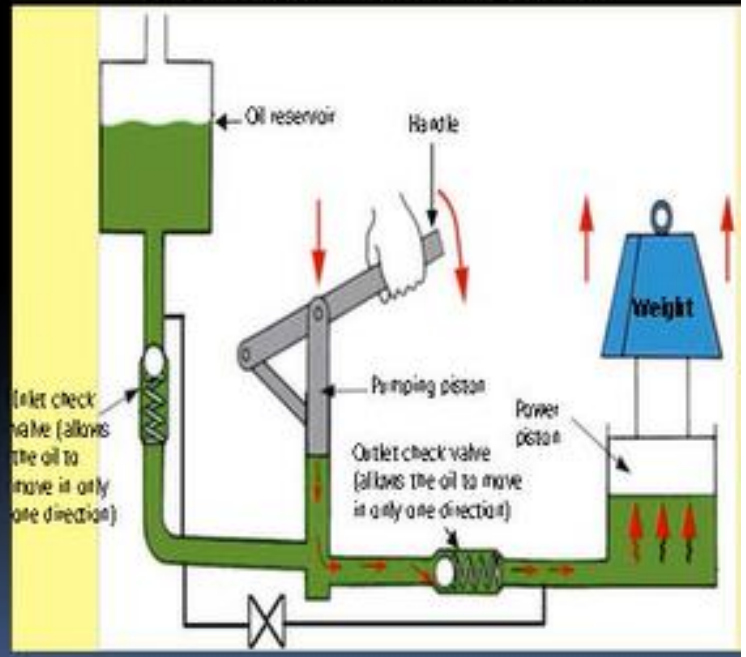
Fig.1.2:Vehicle hydraulic power steering system

2.1 Common examples of hydraulic systems include:

2.1.3 Hydraulic jack

- In a hydraulic jack, a small piston (pumping piston) transmits pressure through the oil to a large piston (power piston) through a check valve, resulting in the weight being lifted as shown in Fig.1.3.
- **Tip: Watch the hydraulic jack video.**

(a) Hydraulic jack

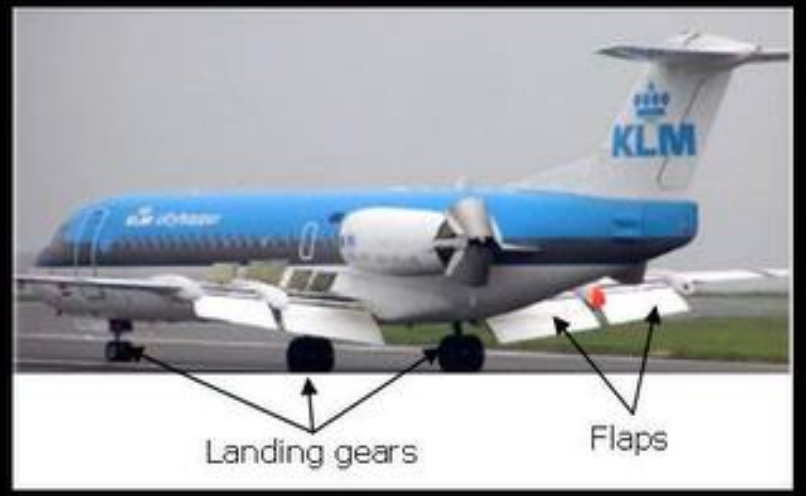


(b) Hydraulic jack schematic diagram

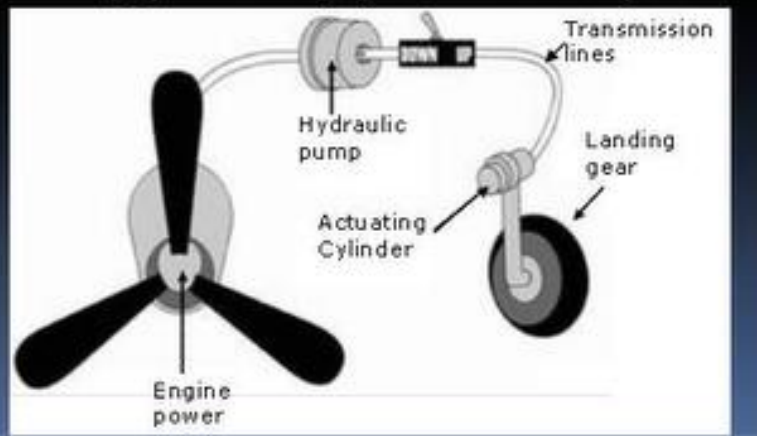
2.1 Common examples of hydraulic systems include:

2.1.4 Aircraft hydraulic systems

- All modern aircraft contain hydraulic systems to operate mechanisms, such as:
- Flaps (Fig. 1.4a)
- Landing gear (Fig. 1.4a)
- The hydraulic pump that is coupled to the engine provides hydraulic power as illustrated by Fig. 1.4b.
- Power is also distributed to systems through the aircraft by transmission lines.
- Hydraulic power is converted to mechanical power by means of an actuating cylinder or hydraulic motor.



(a) Landing gears and flaps

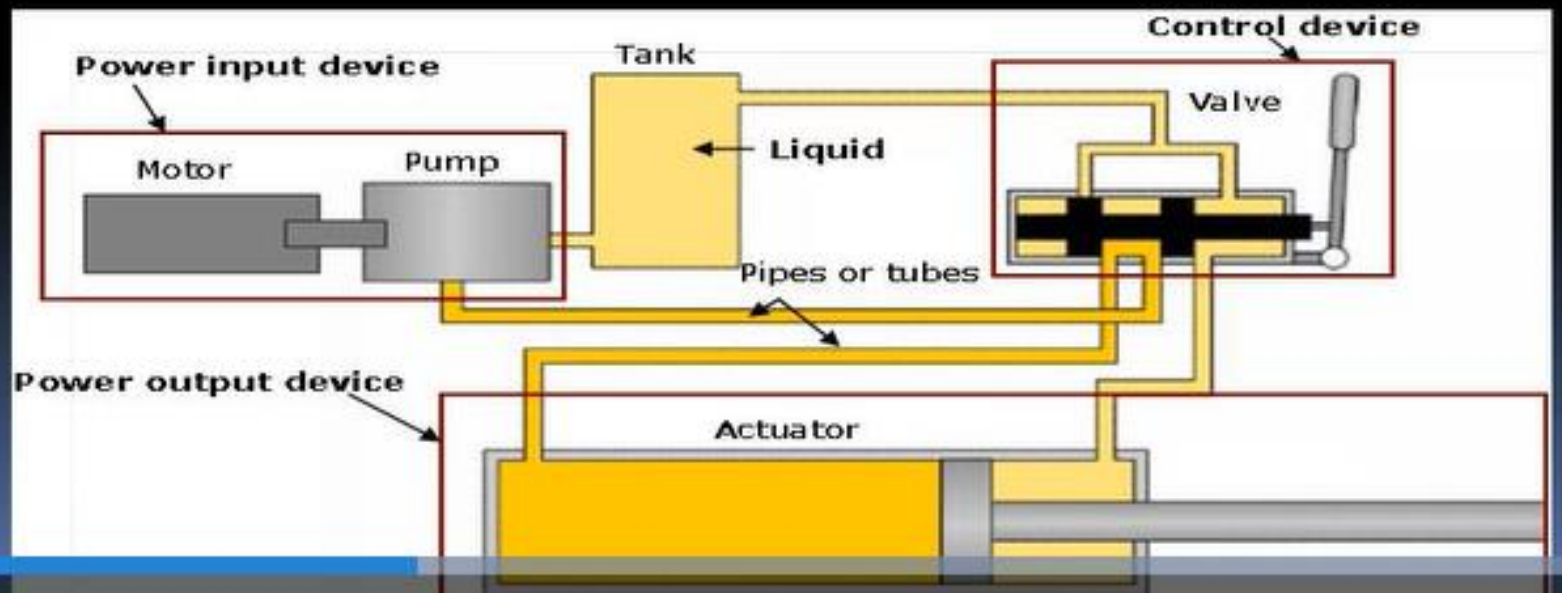


(b) Landing gear schematic diagram

3 Hydraulic system components

- All industrial hydraulic systems consist of the following basic components
- **Power input device:**

  The pump and motor together are called the power input device; the pump provides power to the hydraulic system by pumping oil from the reservoir/tank. The pump's shaft is rotated by an external force which is most often an electric motor as illustrated in Fig 1.5.



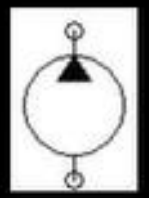
3 Hydraulic system components

- **Control device**: Valves control the direction, pressure, and flow of the hydraulic fluid from the pump to the actuator/cylinder.
- **Power output device**: The hydraulic power is converted to mechanical power inside the power output device. The output device can be either a cylinder which produces linear motion or a motor which produces rotary motion.
- **Liquid**: the liquid is the medium used in hydraulic systems to transmit power. The liquid is typically oil, and it is stored in a tank or reservoir.
- **Conductors**: The conductors are the pipes or hoses needed to transmit the oil between the hydraulic components.

3.3 Hydraulic symbols

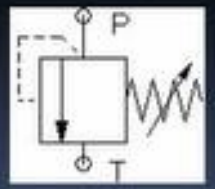
- The way hydraulic components direct and control liquid around a circuit can be complex.
- This would cause difficulty for one engineer explaining to another engineer how the circuit works.
- A common form of representing components and circuits is used to more easily explain what is happening.
- This form of representation uses common symbols to represent components and the ways in which they are connected to form circuits. Fig. 1.7 shows some of the components' symbols used in hydraulics.
- The symbols don't show the component construction, or size, however, it is a standard form that is used by all engineers to represent that specific component.

(a) Electric motor



(b) Hydraulic pump

(c) Tank or reservoir



(d)Pressure relief valve

Fig.1.7: (a) Electric motor. (b) Hydraulic pump. (c) Tank or reservoir. (d) Pressure relief valve.

Pneumatic systems

- Just like other fluids, air exerts pressure on everything that surrounds it. The study of pressure in gases is called pneumatics.
- In **pneumatic systems**, a gas transmits a force exerted on the gas in an enclosed space.
- Pneumatic systems are similar to hydraulic systems, except that gases are used instead of liquids.

Pascal's Law

Pascal's law states that pressure applied to an enclosed fluid is transmitted with equal force throughout the entire container.

Pascal's Law :Hydraulics and Pneumatics

- Pascal's Law applies to both hydraulics and pneumatics:

Property	Hydraulic System	Pneumatic System
State	Liquid	Gas
Volume	Definite	Indefinite
Pressure	Not Compressible	Compressible

Applications of Pascal's Law

Examples of Pascal's law. Include:

(i) a car lift or hoist

(ii) an hydraulic jack

(iii) automobile braking system

(iv) air compressors

(v) automobile/bicycle Tires

Hydraulic Components

- Reservoirs
- Accumulators
- Pumps
- Valves
- Actuators
- Hydraulic motors
- Conductors and connectors
- Hydraulic fluids

Reservoirs

- A reservoir in a hydraulic system has the following roles:
  - Stores hydraulic oil
  - Helps keep oil clean and free of air
  - Acts as a heat exchanger to help cool the oil
- A reservoir is typically equipped with:
    - Filler cap
    - Oil-level gauge or dipstick
    - Outlet and return lines
    - Baffle(s)
    - Intake filter
    - Oil filter
    - Drain plug

Hydraulic Pumps

Hydraulics makes a flexible and efficient form of energy transfer. With the introduction of modern machinery, the need to power them has driven innovations in hydraulic energy; hydraulic pump technology is often chosen for its efficiency and simple designs. Hydraulic pumps are sources of power for many dynamic machines. Different hydraulic pump types are capable of pushing large amounts of oil through hydraulic cylinders or hydraulic motors. In this article, we'll

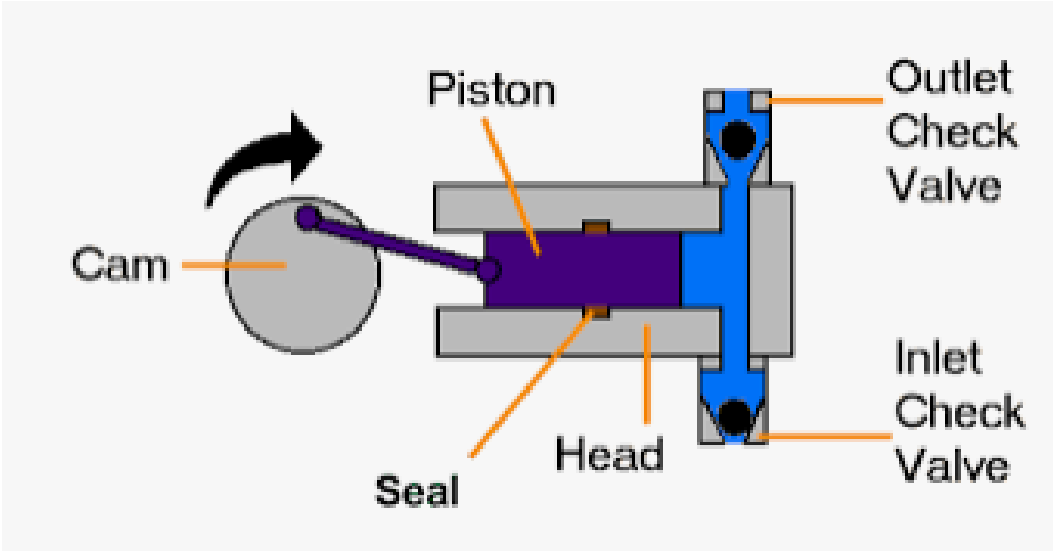
Classification of pumps

- Non-positive-displacement pumps
  - Centrifugal pumps
  - Axial pumps
  - Radial pumps
- Positive-displacement pumps
  - Reciprocating pumps
  - Rotary pumps
    - Gear pumps
      - External gear pumps
      - Lobe pumps
      - Internal gear pumps
      - Gerotor pumps
    - Screw pumps
    - Vane pumps
    - Piston pumps
      - Axial piston pumps
      - Radial piston pumps

All pumps may be classified as either positive-displacement or non-positive-displacement. Most pumps used in hydraulic systems are positive-displacement.

- **Reciprocating pumps:** The reciprocating type pump is the most elementary positive-displacement pump. As the piston extends, the partial vacuum created in the pump chamber draws liquid from the reservoir through the inlet check valve into the chamber. The partial vacuum helps seat firmly the outlet check valve. The volume of liquid drawn into the chamber is known because of the geometry of the pump case, in this example, a cylinder.

As the piston retracts, the inlet check valve reseats, closing the valve, and the force of the piston unseats the outlet check valve, forcing liquid out of the pump and into the system. The same amount of liquid is forced out of the pump during each reciprocating cycle.



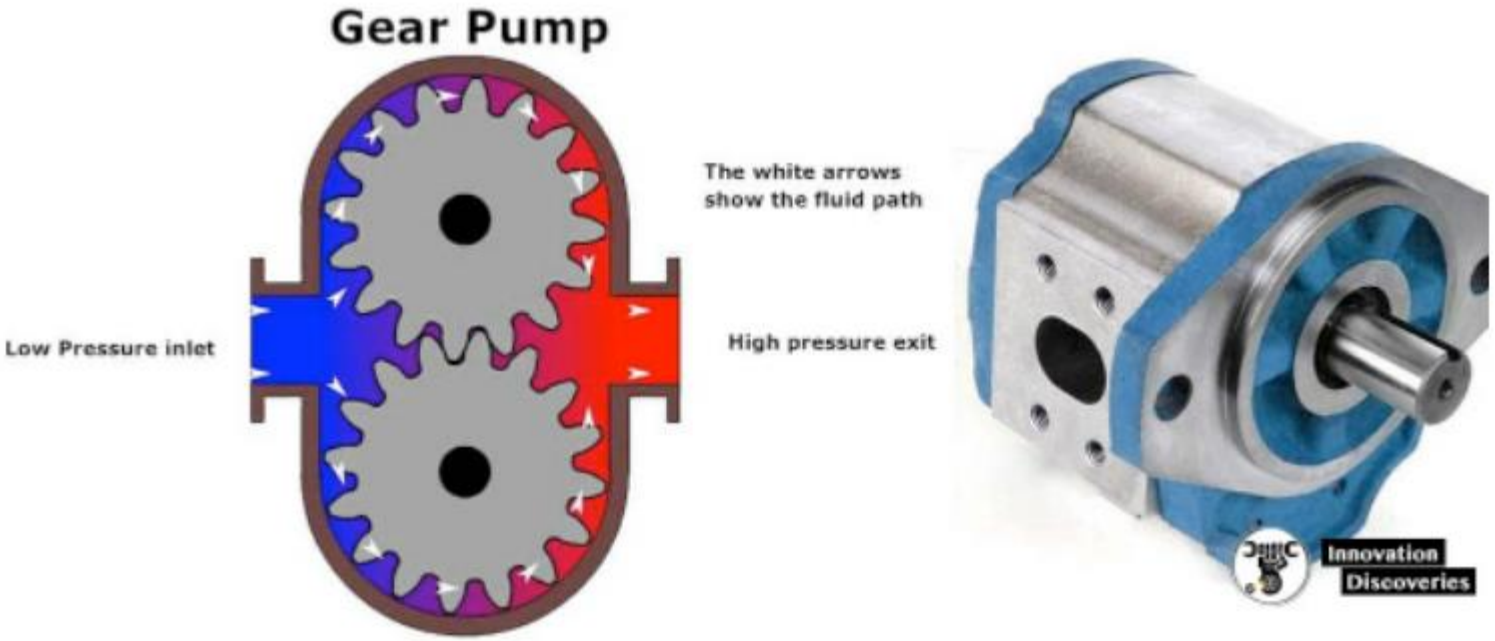
- **Gear Pumps:** Probably the simplest and most commonly used types of hydraulic pumps today and they are easily maintained and economic. This design is characterized as having fewer moving parts, being easy to service, more tolerant of contamination than other designs, and relatively inexpensive. Gear 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. Gear pumps are rated in terms of the pump's maximum pressure rating, cubic inch displacement, and maximum input speed limitation.

Gear Pumps

- Gear pumps are widely used in mobile hydraulics because of their simplicity.
- They are also widely used to move fuel through diesel fuel subsystems and as engine lube oil pumps.
- Three types of gear pumps are used:
  - External gear
  - Internal gear
  - Rotor gear

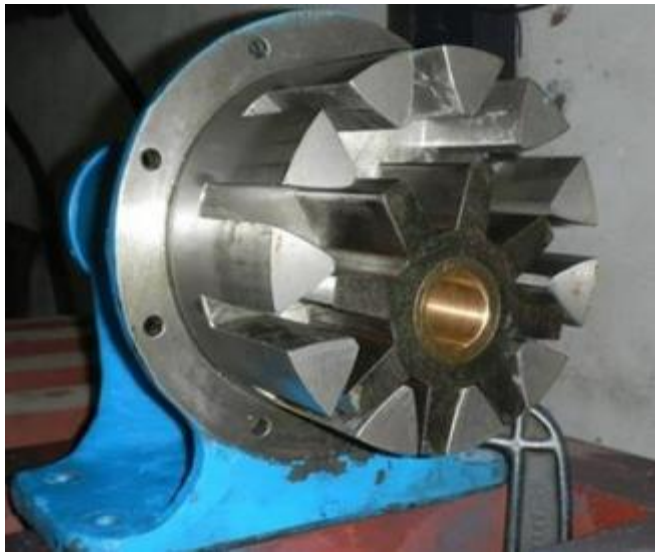
Internal gear pump

An internal gear pump **moves a fluid by repeatedly enclosing a fixed volume within interlocking gears**, transferring it mechanically to deliver a smooth pulse-free flow proportional to the rotational speed of its gears.



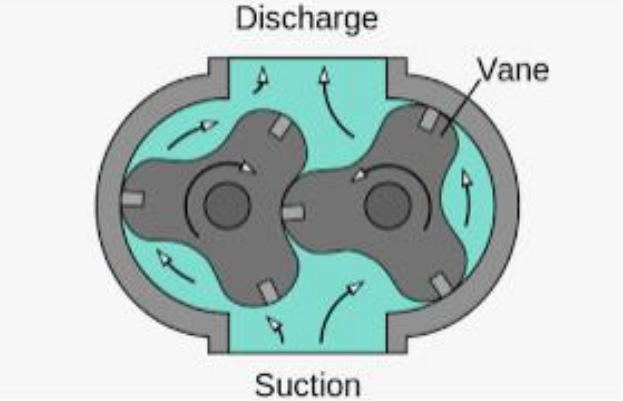
Internal gear pump

- A spur gear rotates within an annular internal gear, meshing on one side of it.
- Both gears are divided on the other side by a crescent-shaped separator.
- When an external gear is in mesh with an internal gear, they both turn in the same direction of rotation.
- As the gear teeth come out of mesh, oil from the inlet is trapped between the teeth and the separator and is carried to the outlet and expelled.



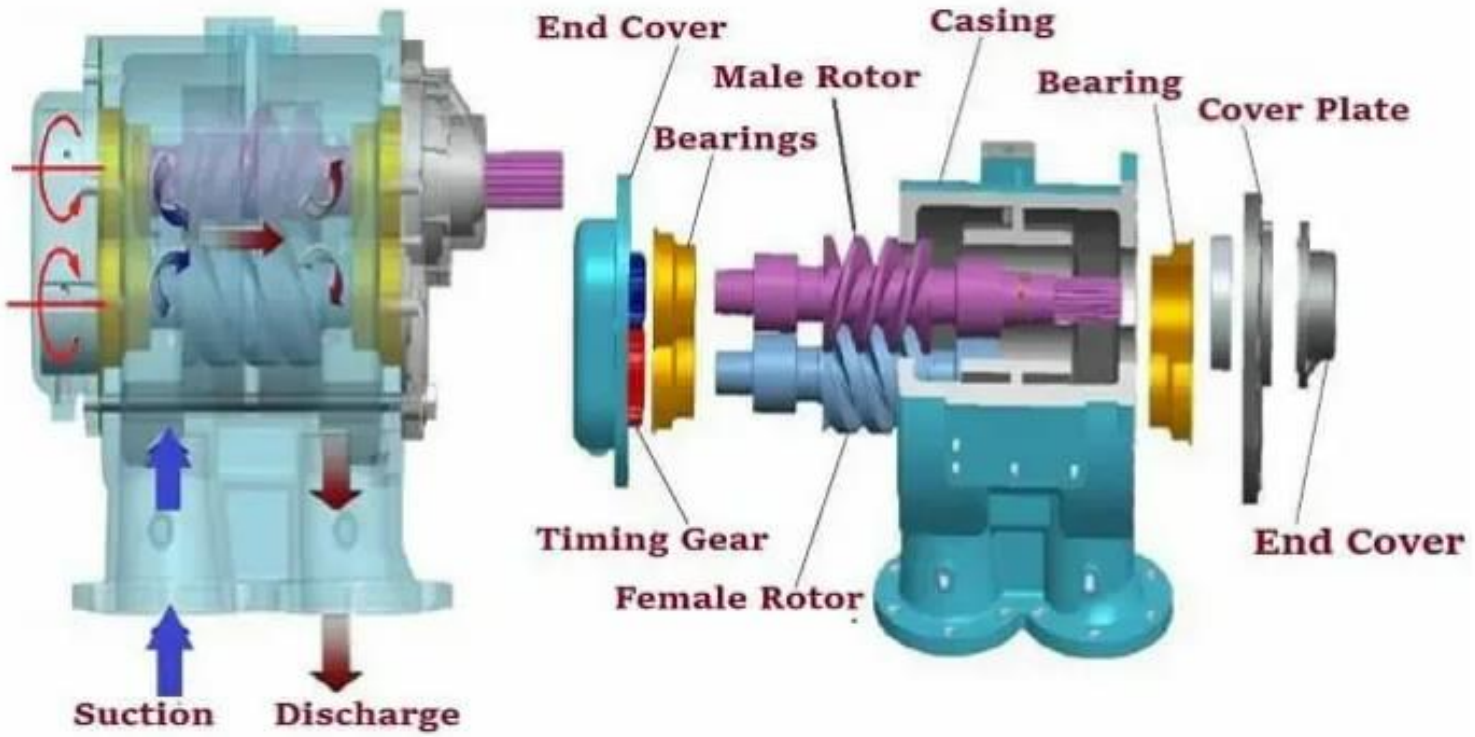
Lobe Pump

Rotary lobe pumps are positive-displacement type pumps that use two or more lobes rotating around parallel shafts in the pump's body to move liquids. They are widely used in the hygienic processing industries, including food & beverage processing and biopharmaceutical manufacturing.



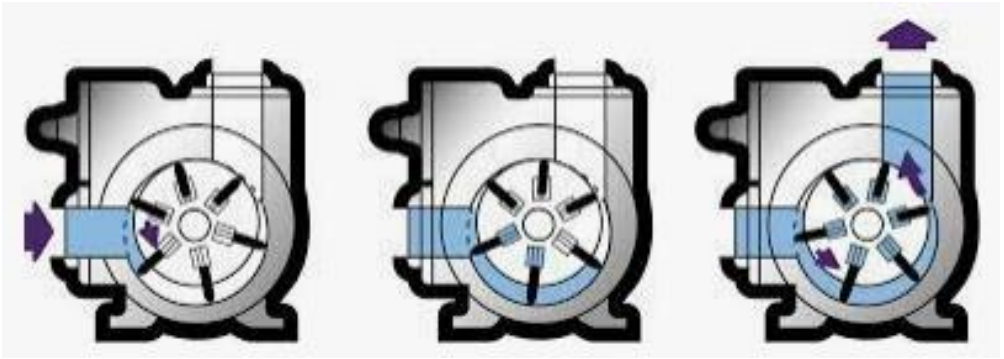
Screw Pumps

Screw pumps belong to the family of dry compressing gas transfer pumps. They are positive-displacement pumps that use two screw shaped intermeshing rotors to move gas along the screw's axis. They are frequently used in industrial vacuum applications, often in combination with roots blowers and as oil-free roughing pumps in high and ultrahigh vacuum systems.



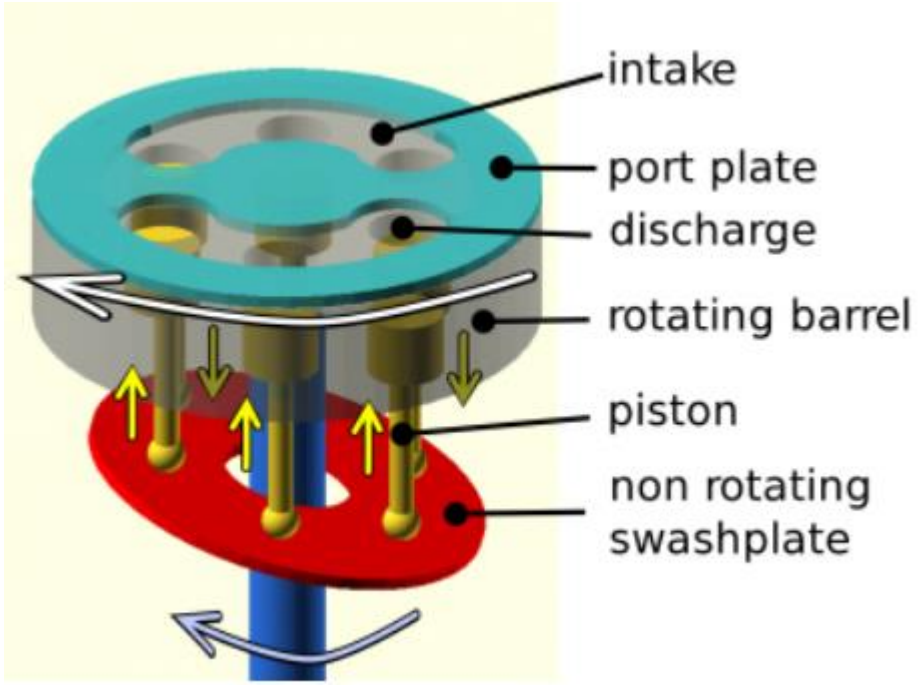
Vane Pump

A vane pump is a self-priming positive displacement pump providing constant flow at varying pressures. Operation is via a motor connected to a gearbox as typically the maximum rpm is 900. The pump is fitted with a relief valve to prevent the pump from building to a pressure which may damage the pump.



Piston Pump

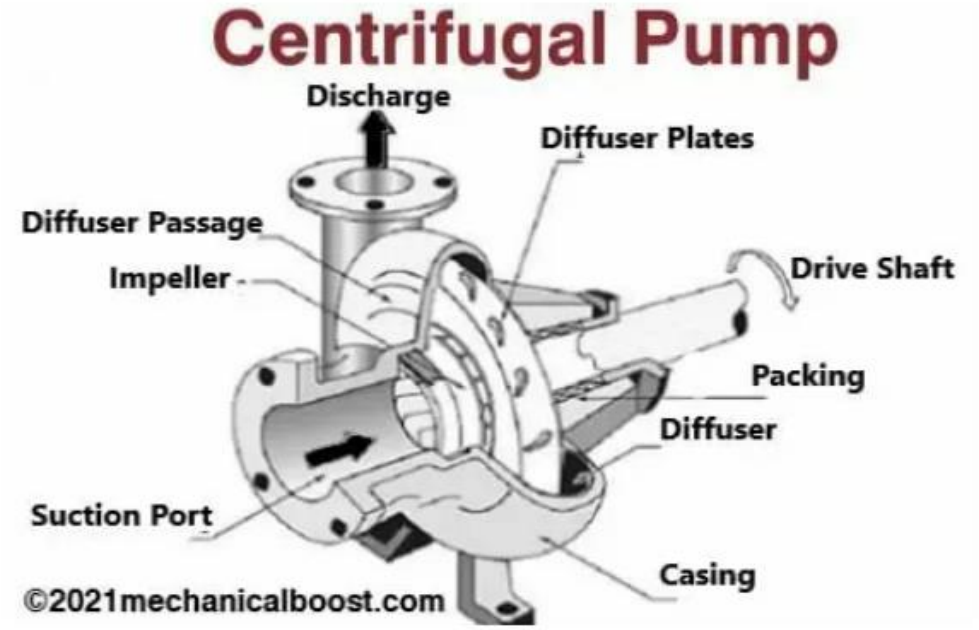
The piston pump can be defined as it is a positive displacement pump. These pumps use a piston, diaphragm, otherwise plunger for moving liquids. These pumps use check valves as the input and output valves. The general piston-pump is a rotary pump which uses a wheel or revolving shaft for operating the piston.



Piston Pump

Centrifugal Pump

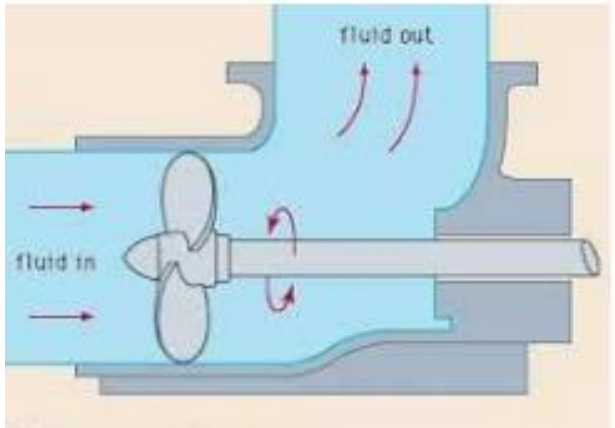
A centrifugal pump is a mechanical device designed to move a fluid by means of the transfer of rotational energy from one or more driven rotors, called impellers. Fluid enters the rapidly rotating impeller along its axis and is cast out by centrifugal force along its circumference through the impeller's vane tips. The action of the impeller increases the fluid's velocity and pressure and also directs it towards the pump outlet. The pump casing is specially designed to constrict the fluid from the pump inlet, direct it into the impeller and then slow and control the fluid before discharge.



Axial Pump

An **axial flow pump** is a type of dynamic pump which has a suction parallel to the **impeller direction**. An axial flow pump doesn't change the flow direction of the fluid. In this pump, the **fluid enters** and **exits** the pump in the parallel direction to the **impeller**. It has an impeller inside the pipe. This pump has three to four blades that are installed on the impeller.

The pump blades design in such a way that the pump discharges the water axially in the parallel direction to the impeller nor perpendicular. The parallel alignment of the impeller blades creates a very low pressure when pumping water. These pumps use for high flow rate and low pressure applications.

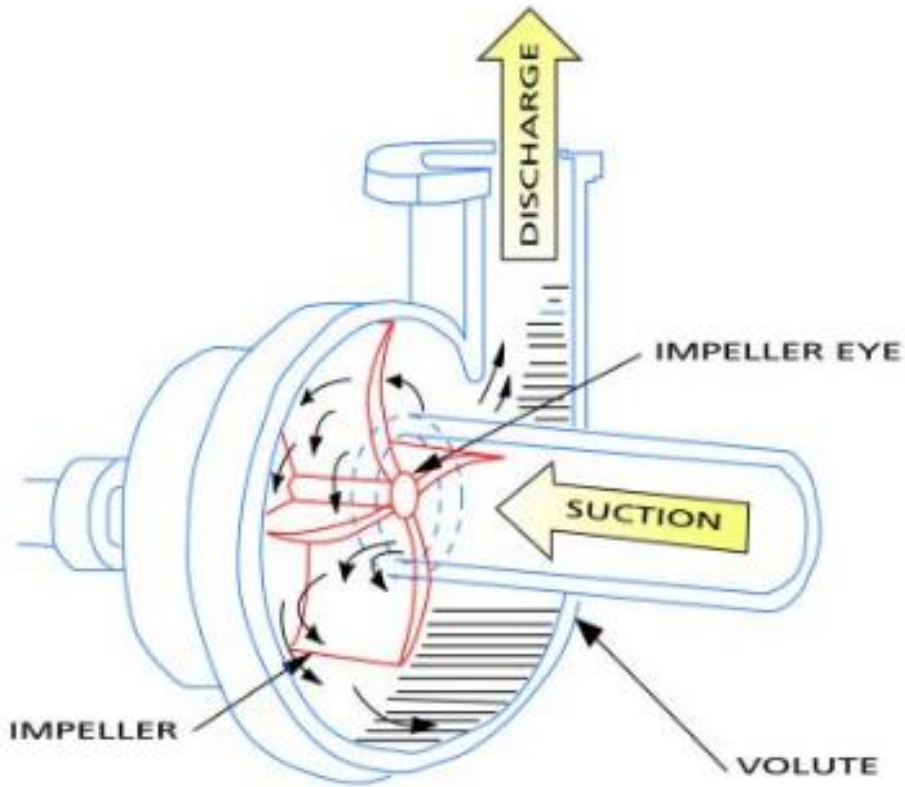


Radial Pump

Their name suggests how radial pumps work. With these pumps, the fluid handled is conveyed radially: It enters via the suction pipe, is collected by the impeller, and then escapes vertically to the pump shaft from the pump's impeller and through a spiral casing. This materials handling method that uses centrifugal force enables higher pressures than can be achieved with axial pumps, where the fluids are conveyed axially, that is, parallel to the pump shaft.

Radial pumps are suitable for handling incompressible fluids, which can also contain gases or small percentages of solids. Generally, centrifugal pumps are used to handle water. More precise applications can include drinking water, cooling water, wastewater and sewage, handling in the course of water treatment, and filling and emptying tanks.

But radial pumps can handle many other fluids. Generally, all water-like and low-viscosity media are possible. These include different kinds of fuels, refrigerants & coolants, fluid gases, fluids that contain gases, fluid hydrocarbons, acids and alkalis. They can even be used for oils if the viscosity is not too high and many other fluids in addition to those named above.



Radial Flow Pump

Pump Comparison: Centrifugal vs Positive Displacement

Property	Centrifugal	Positive Displacement
Effective Viscosity Range	Efficiency decreases with increasing viscosity (max. 200 Cp)	Efficiency increases with increasing viscosity
Pressure tolerance	Flow varies with changing pressure	Flow insensitive to changing pressure
	Efficiency decreases at both higher and lower pressures	Efficiency increases with increasing pressure
Priming	Required	Not required
Flow (at constant pressure)	Constant	Pulsing
Shearing (separation of emulsions, slurries, biological fluids, food stuffs)	High speed damages shear-sensitive mediums	Low internal velocity. Ideal for pumping shear sensitive fluids

Hydraulic Control Systems

- Directional Control Valves : For determine the direction of the Actuator
- Pressure Control Valves : For control the force on Actuator
- Flow Control Valves : For control the speed on Actuator

Directional Control Valves

The description of directional valves is standardized by **DIN ISO 1219.**

Basics of the ISO symbols:

- Each position the valve can take is represented by a square.
- The number of squares tells you the number of positions the valve can take.
- The air pathways are represented by lines.
- The direction of the airflow is represented by an arrow.
- In case air flows in both directions there is a double arrow.
- Closed ports are displayed as a T.
- The ports carry numbers. The numbers are only shown in the square with the basic position of the valve.
- The type of actuation is also symbolized.
- The ISO-symbol contains information concerning the stability of the positions and the reset.

Directional valves – number of ports and positions

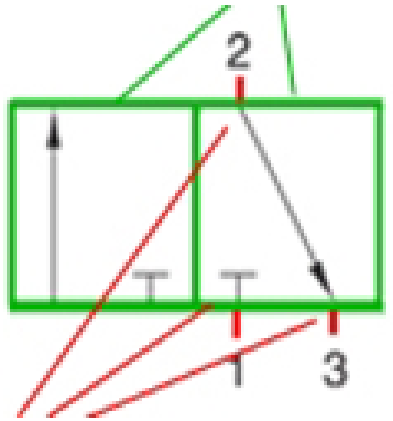
The directional valves are described by the numbers of ports in the main valve (excluding pilot ports) and the number of positions the valve can take, **[number of ports] / [number of positons]**

for example:

2 squares = 2 positons

3 ports

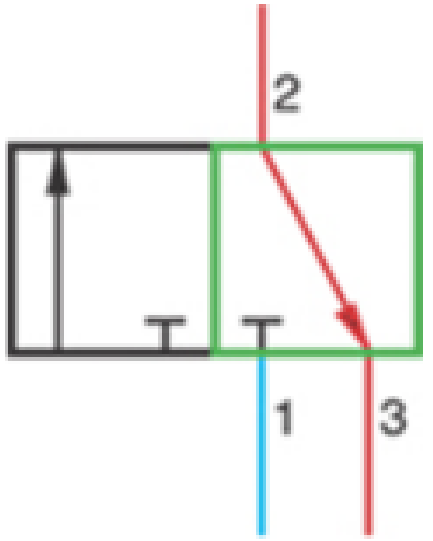
Number of positions



Number of ports

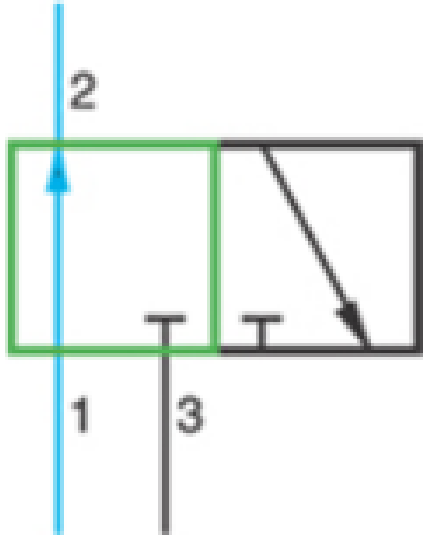
On the right hand side you can see the basic position of a normally closed 3/2-way valve.

- Port 1 = pressure supply is closed (blue).
- Port 2 = working, in basic position connected to port 3 = exhaust (red).
- Basic position or normal position drawn in green.



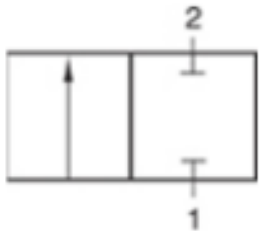
The second square displays the actuated position of the valve.

- Valve has been actuated (actuation elements not shown here).
- Port 1 is connected to working port 2 (blue).
- Exhaust port 3 is closed (black).
- Actuated positon drawn in green.

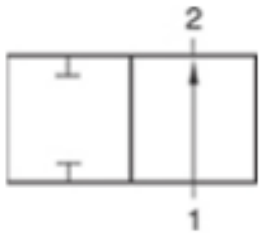


Symbols of the most common valves

2/2-way valve

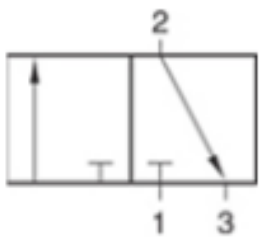


Normally closed

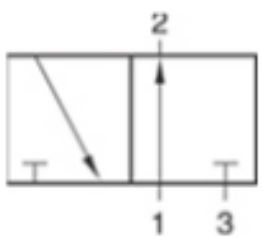


Normally open

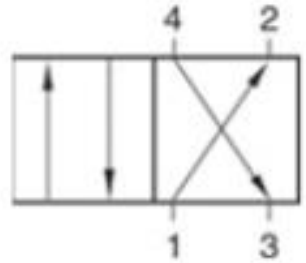
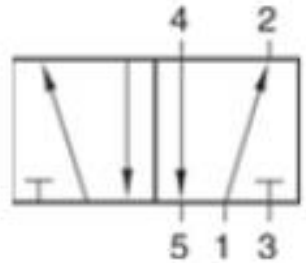
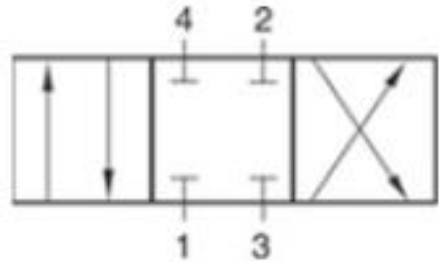
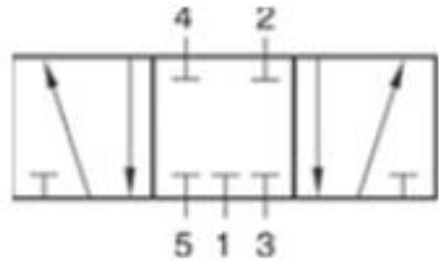
3/2-way valve



Normally closed

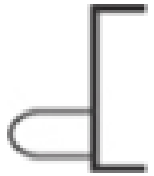
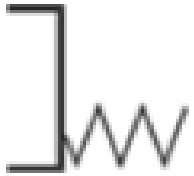
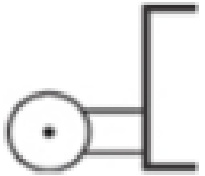
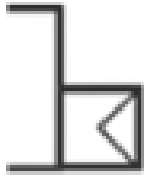
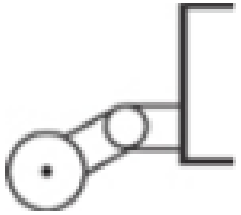


Normally open

4/2-way valve		
5/2-way valve		
4/3-way valve		Center closed
5/3-way valve		Center closed

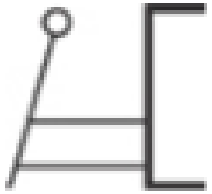
Symbols of actuation elements and resets

Apart from the squares showing the valve's function, the symbols for its actuation elements and elements to reset/return it are shown on the left, respectively right side of them.

Mechanically actuated, Actuation by stem			With spring reset
Mechanically actuated, Actuation by roller lever			With air spring reset
Mechanically actuated, Actuation by roller lever with idle return			With combined (mechanical) spring and air spring reset

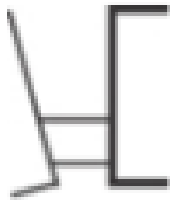
Manually actuated,
Actuation with a push-button

Manually actuated,
Actuation by a lever

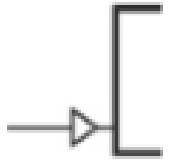


Manually actuated,
Actuation by a lever, indexed, 2 positions

Actuated by foot / foot valve

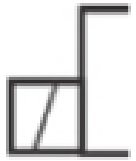


Pneumatically actuated



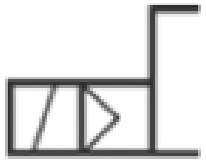
Electrically actuated,

Direct actuated valve



Electrically actuated,

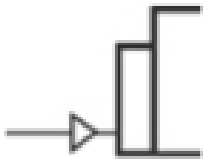
Solenoid pilot valve

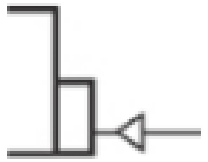


Manual override

Pneumatically actuated,

Differential piston, dominating side





Pneumatically actuated,

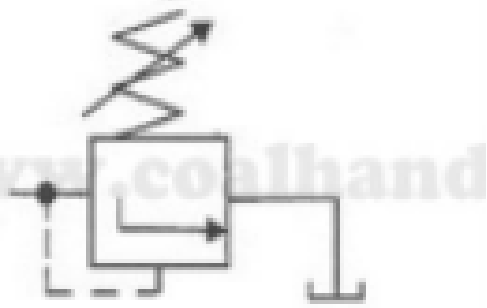
Differential piston.

Pressure Control Valves

The function of a hydraulic pressure control valve is to regulate the pressure of the fluid travelling through the pipe in a hydraulic system. This is done by maintaining the required pressure and keeping it at a safe level, whilst releasing any excess pressure that may cause pipes to leak or burst.

Typically, some form of pressure control valve will be found in every hydraulic system. Different types offer a variety of functions depending on the requirements of the application, ~~such as:~~

I. Pressure Relief Valve – They are designed to protect hydraulic system when pressure in the system increases beyond the specified design pressure or maximum working pressure. They are normally closed and it opens when the pressure exceeds a specified maximum value and diverts the pump flow back to reservoir or tank internally. They are located near hydraulic pump.

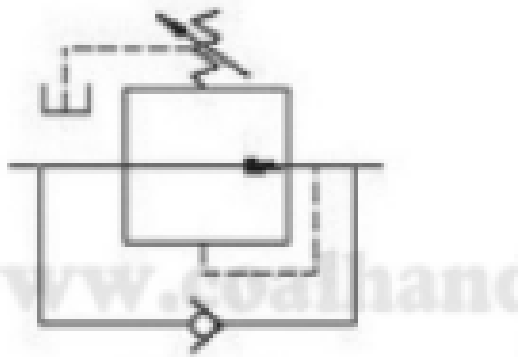


PRESSURE RELIEF VALVE

Pressure reducing valves

Unlike pressure relief valves which control the input pressure, reducing valves work to control the output pressure. For example, if the output pressure of a hot water system is too high, this can affect the water flow and overall performance of the system.

A pressure reducing valve will help to ensure a consistent flow of water by reducing the pressure in one part of the circuit to a lower level than the system pressure, to achieve the set value.



PRESSURE REDUCING VALVE

Pressure valves with fixed throttle

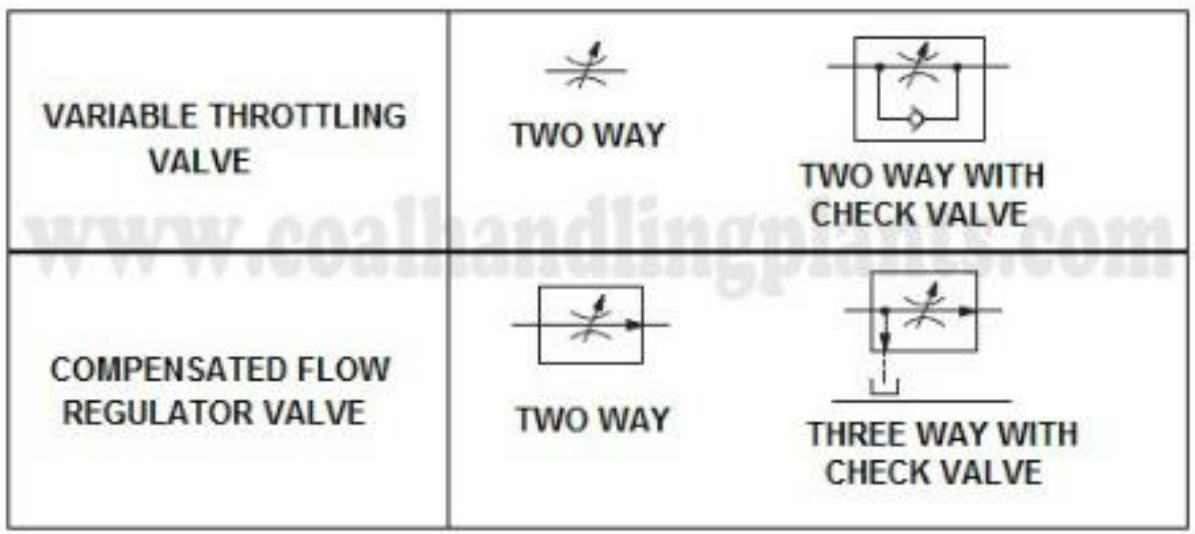
These types of valves also offer pressure controlling capabilities, with the assistance of a switching task to allow a change in the position of the valve to happen suddenly when required, as opposed to gradually as with other pressure valves. These can be divided into two categories:

- **Sequence valves** operate by directing the flow to another part of the hydraulic circuit when the set pressure is reached.
- **Unloading valves** direct the flow back to the tank when the maximum pressure has been reached in a specific location of the circuit.

Flow Control Valves

A flow control valve is used for adjusting the flow rate of a fluid in a pipeline. The valve contains a flow passage or a port whose area can be varied.

Symbol Of Flow Control Valve Used In Hydraulic System Circuit Diagram



Hydraulic Actuators

An actuator is a mechanical or electro-mechanical device that converts energy from a control signal into mechanical motion. In simpler terms, an actuator is a device that allows controlled movement or positioning.

Actuators need a control signal and a source of energy to bring about mechanical motion. Actuators use an energy source – such as electrical, compressed air, or hydraulic pressure – and a control signal that can be manual, an automatic electronic system, a fixed mechanical system, a software-run system or a robotic control system.

From regulating the flow of fuel to a gas turbine, to operating valves and hydraulic cylinders in industrial plants, actuators serve the general purpose of controlling movement, and are a key component in several industrial valve control applications.

Types of actuators: Based on motion

Actuators can create two main types of motions – linear and rotary.

- *Linear actuators*: Linear valve actuators are used to turn electric, pneumatic, and hydraulic energy into a push-and-pull motion or linear movement. A linear actuator can create both a forward and backward movement on a set linear plane. Most of the equipment found in food and beverage processing plants that require a straight motion use linear valves to control the flow of raw materials and finished products.
- *Rotary actuators*: Rotary actuators move in a circular motion. Machines that have rotating parts have a rotary actuator to complete a turning movement on a circular plane. Rotary actuators are extensively used on control valves and ball valves. A rotary actuator can keep rotating in a given direction and they can go back and forth. Rotary valve actuators are often used in the oil and gas industry.

Linear and rotary actuators may be used together in instances where a mechanism necessitates operation in two planes of motion, requiring both rotational movements, clockwise and counterclockwise, as well as linear movement up and down.

Types of actuators: – Source of energy

The different types of actuators classified according to the source of energy are given below

Pneumatic actuators: Pneumatic actuators use a vacuum or pressurized gas to act as a piston inside a cylinder to create mechanical movement.

There are single-acting cylinders that have one port where pressurized gas enters in one direction. The compressed air forces the piston to move in one direction compressing a spring which is fitted to the piston. Double-acting cylinders extend and retract without a spring and have two ports where air can enter in and out.

Pneumatic-powered actuators are preferred because they are safe, generally fast, cost-effective and can produce large amounts of torque with small pressure changes. Due to the high pressure involved to power a pneumatic actuator, these valves respond quickly, and are the preferred choices in applications where you need to stop and start the main controls immediately.

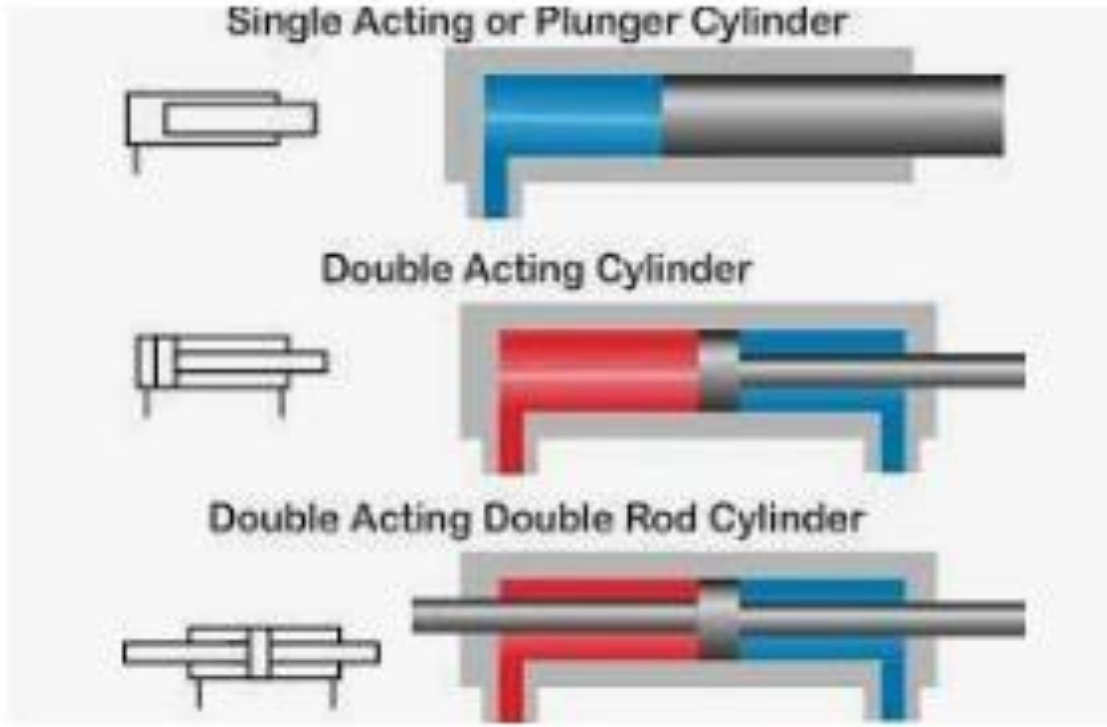
Among many other uses, pneumatic actuators are often employed on valves used to control cooling water flow in power plants.

Electrohydraulic actuators: These actuators are powered electrically, but give movement to a hydraulic accumulator, which in turn provides the force for the movement. When these actuators are used, there is no need for a separate hydraulic pump; this lowers the cost, and enhances reliability and safety.

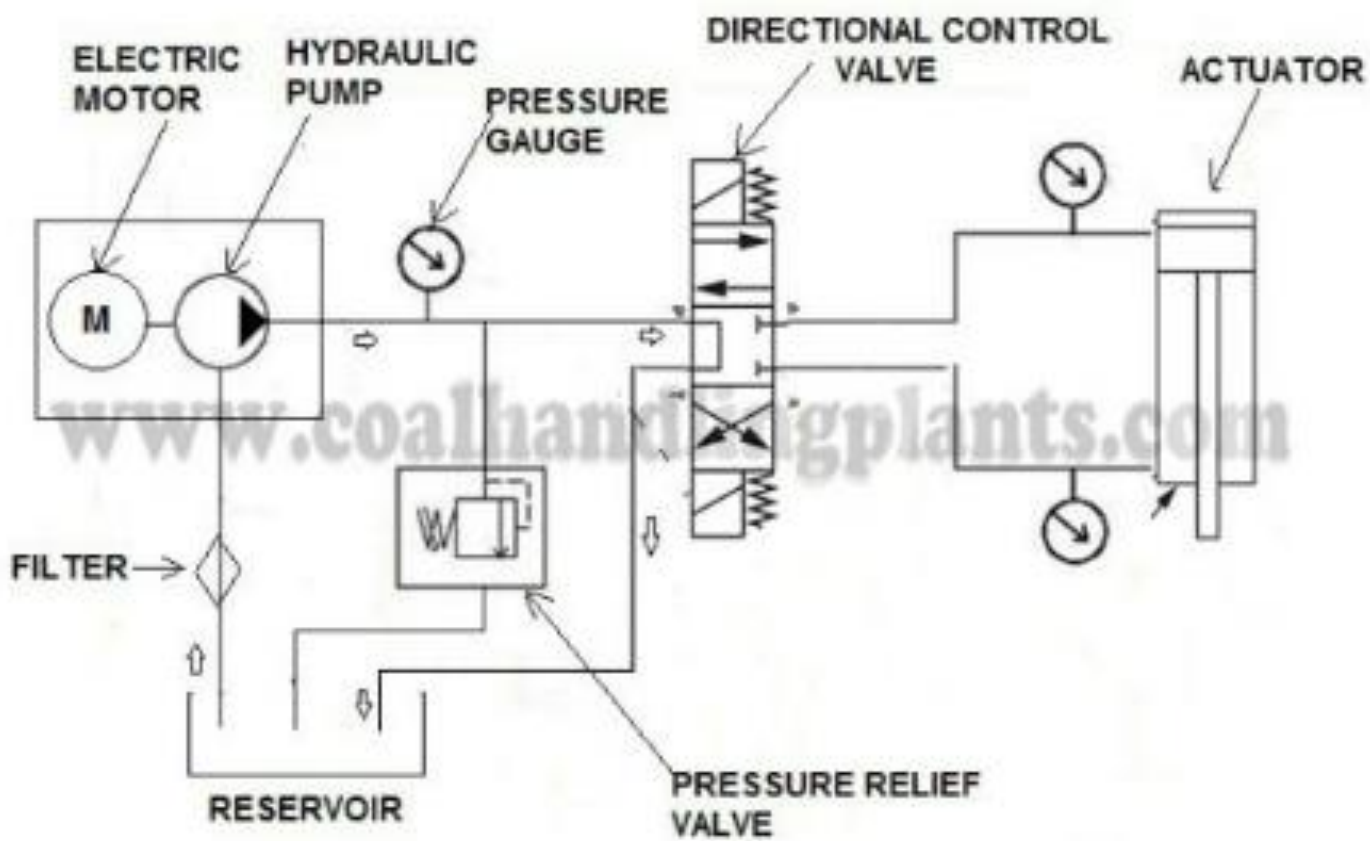
Hydraulic actuators: Hydraulic actuators have a cylinder, or a fluid motor with a piston, that uses hydraulic power to generate mechanical motion. The mechanical motion in turn is converted to linear, rotatory, or oscillatory motion as per the application.

Liquids are almost incompressible; the density changes caused by pressure and temperature are negligible. For this reason, the amount of torque generated from a hydraulic actuator valve is high, making it very powerful. There are single-acting hydraulic actuator valves that apply pressure on one side of the pistons, moving it in the opposite direction. A spring would be necessary for the reverse motion. On the other hand, double-acting hydraulic actuators apply pressure on both sides of the piston for a movement from both sides.

Some applications where hydraulic actuators are used are in the main stop and control valves for high-pressure steam turbine piping.


Single Acting or Plunger Cylinder
Double Acting Cylinder
Double Acting Double Rod Cylinder

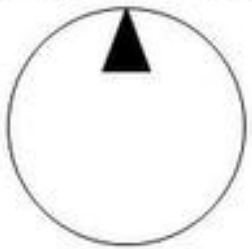
Hydraulic System Components And Hydraulic Circuit



Differences in Symbols

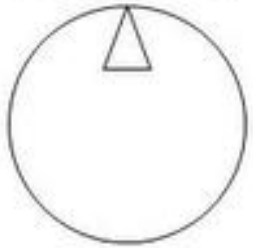
Symbols Reminder

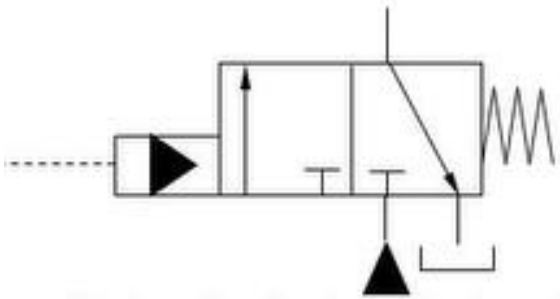
Hydraulic Pump



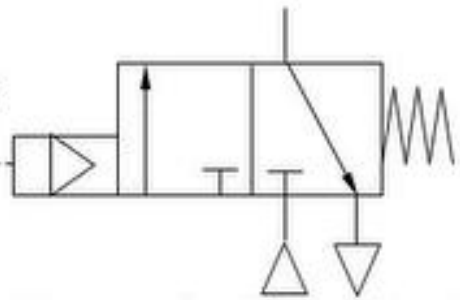
Pumps and Motors differ only by filling in the direction arrow or leaving it white.

Compressor





Supply and Pilot arrows are also filled in or left white.

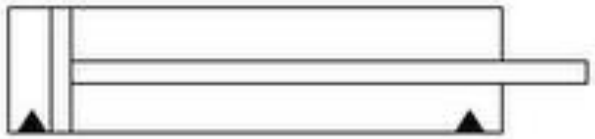


Hydraulically Actuated and supplied 3/2 Pilot Spring

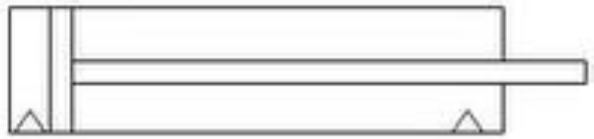
Pneumatically Actuated and supplied 3/2 Pilot Spring

Differences in Symbols

Cylinders and other actuators also differ with respect to supply and direction arrows.

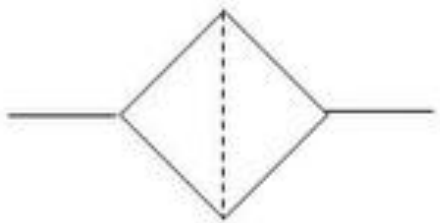


Hydraulic Double Acting Cylinder

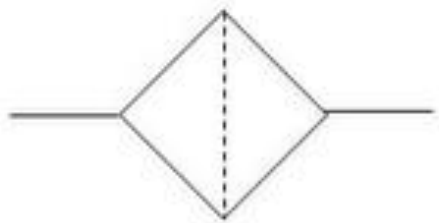


Pneumatic Double Acting Cylinder

Many symbols do not change, for example the **Filter** symbol.



Hydraulic Filter



Pneumatic Filter

Input / Output

Force input on a hydraulic system or component results in transfer of power to output of force by the system or component.

Pump

Functions in a hydraulic system by pressurizing and moving fluid from one part of the system to another.

තරලයට ශක්තිය එක් කරන තරල යන්ත්‍ර

- පොම්ප
  - පිස්ටන් පොම්ප
  - ප්‍රාචීර පොම්ප
  - ගියර පොම්ප
  - ලෝබ් පොම්ප
  - වේන් පොම්ප
  - ඉස්කුරුප්පු පොම්ප
  - අක්ෂීය පොම්ප
  - අරීය (කේන්ද්‍රාපසාරී) පොම්ප

Piston Pumps

- Work well at PSI’s of 2000 or more
- Single piston pump used in bottle jacks
- Require several pistons working together to generate enough volume for tractor applications
- Necessarily involve many moving parts

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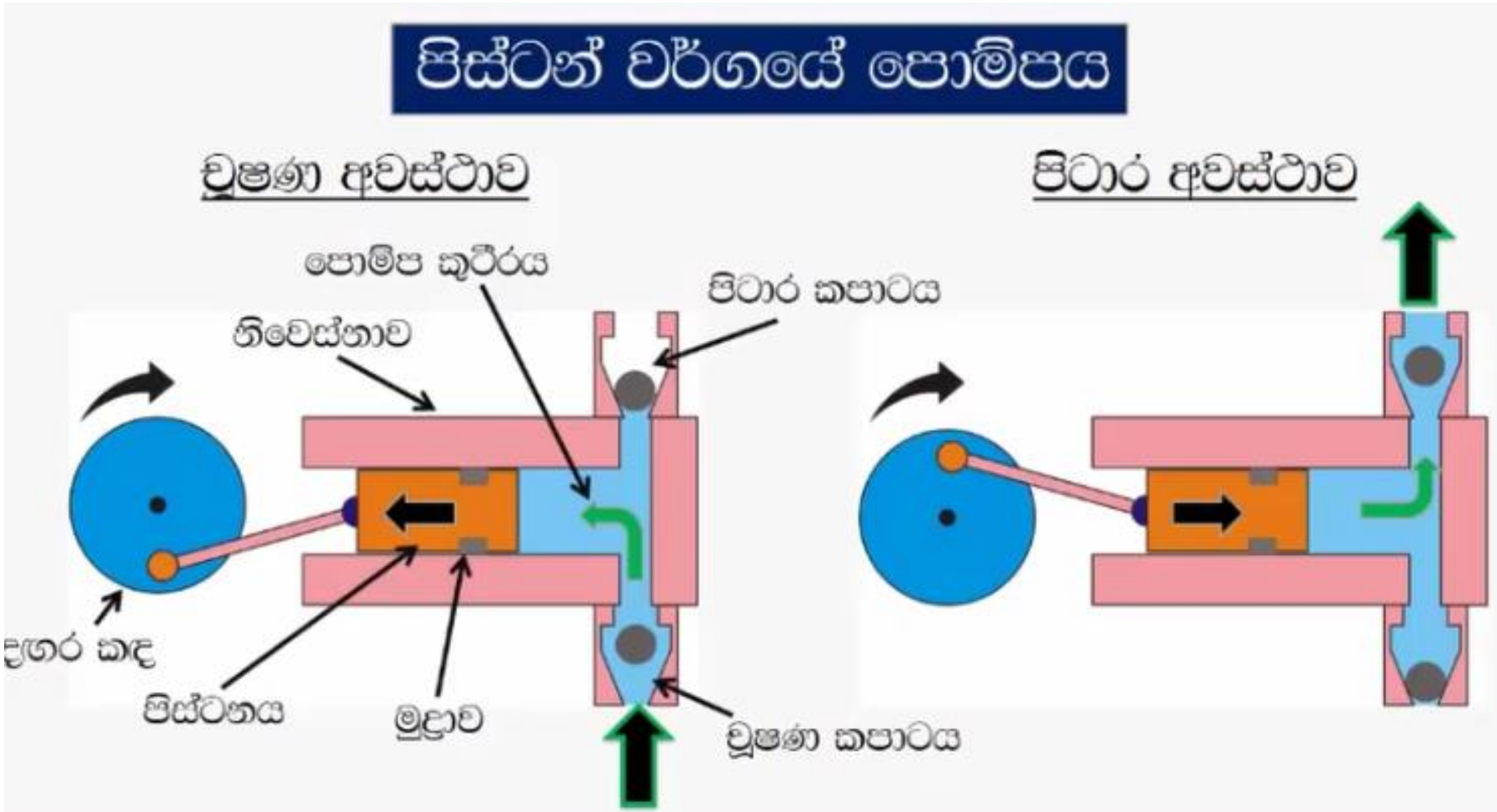
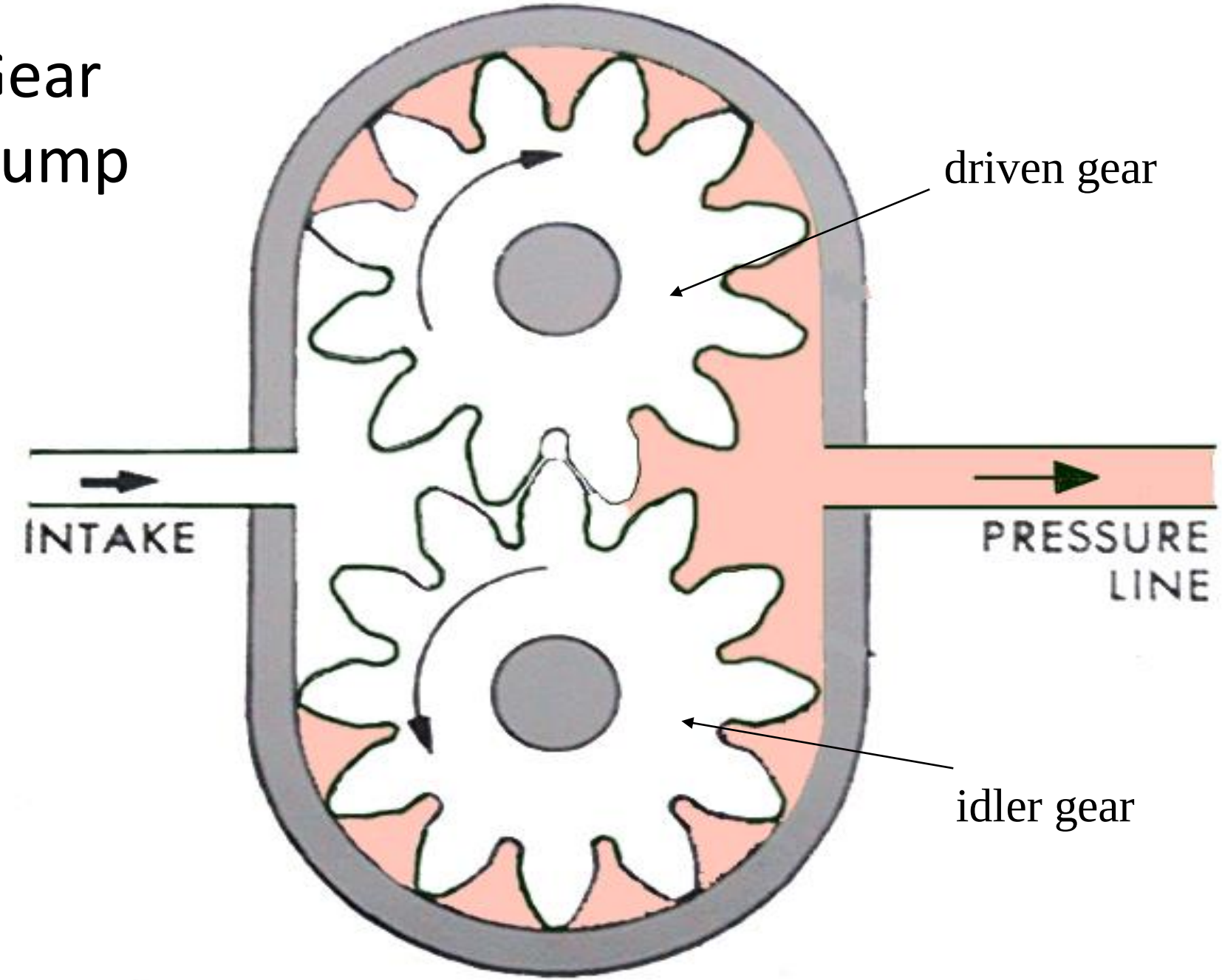


Gear Pumps

- Work well at 1500 PSI and below
- Work with a minimum of moving parts
- Less expensive to manufacture than piston type pumps

Gear Pump



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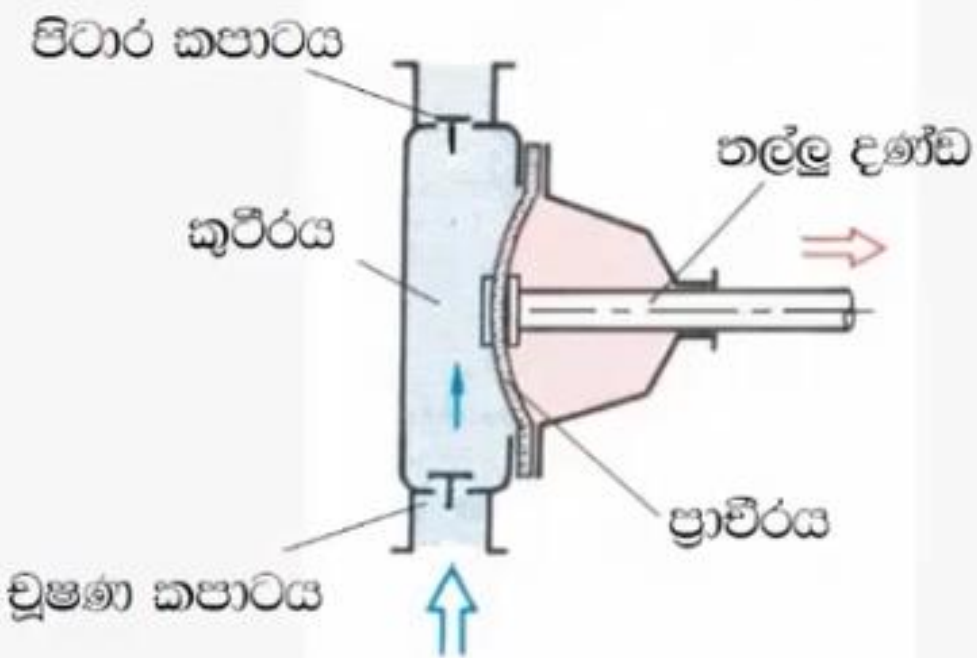
චූෂණ අවස්ථාව



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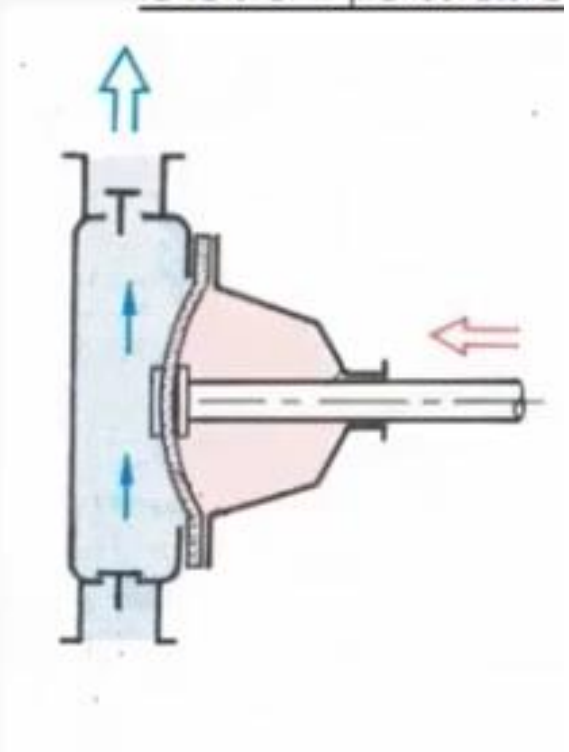

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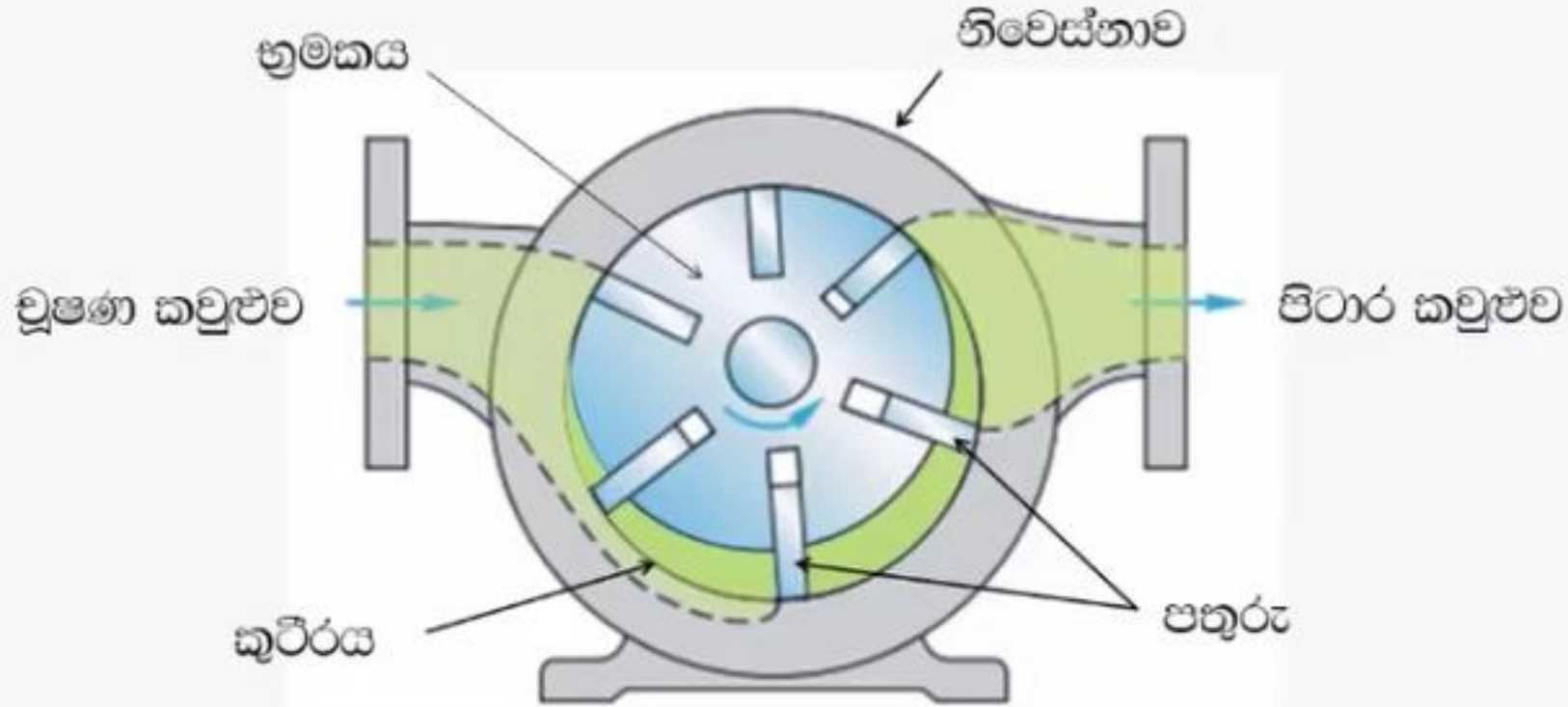
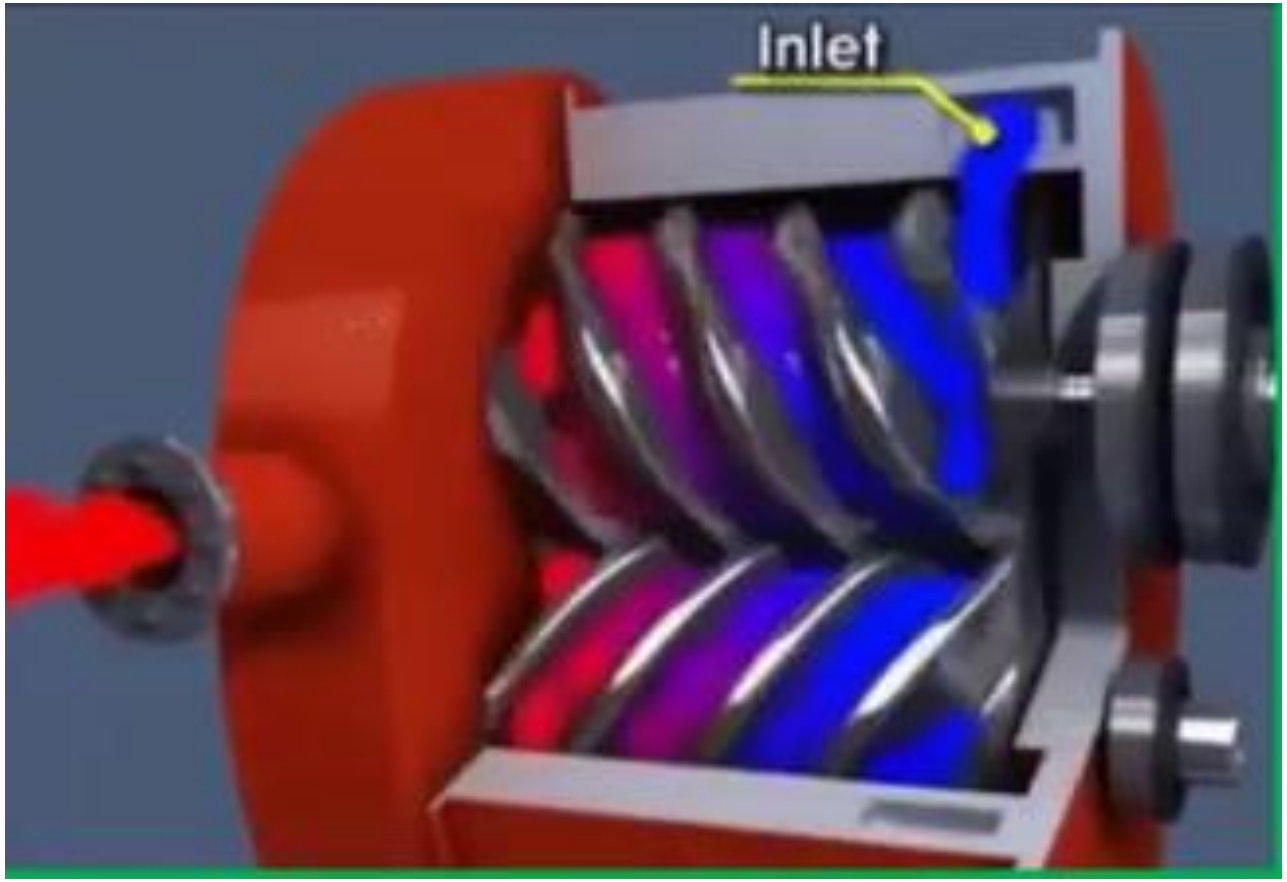
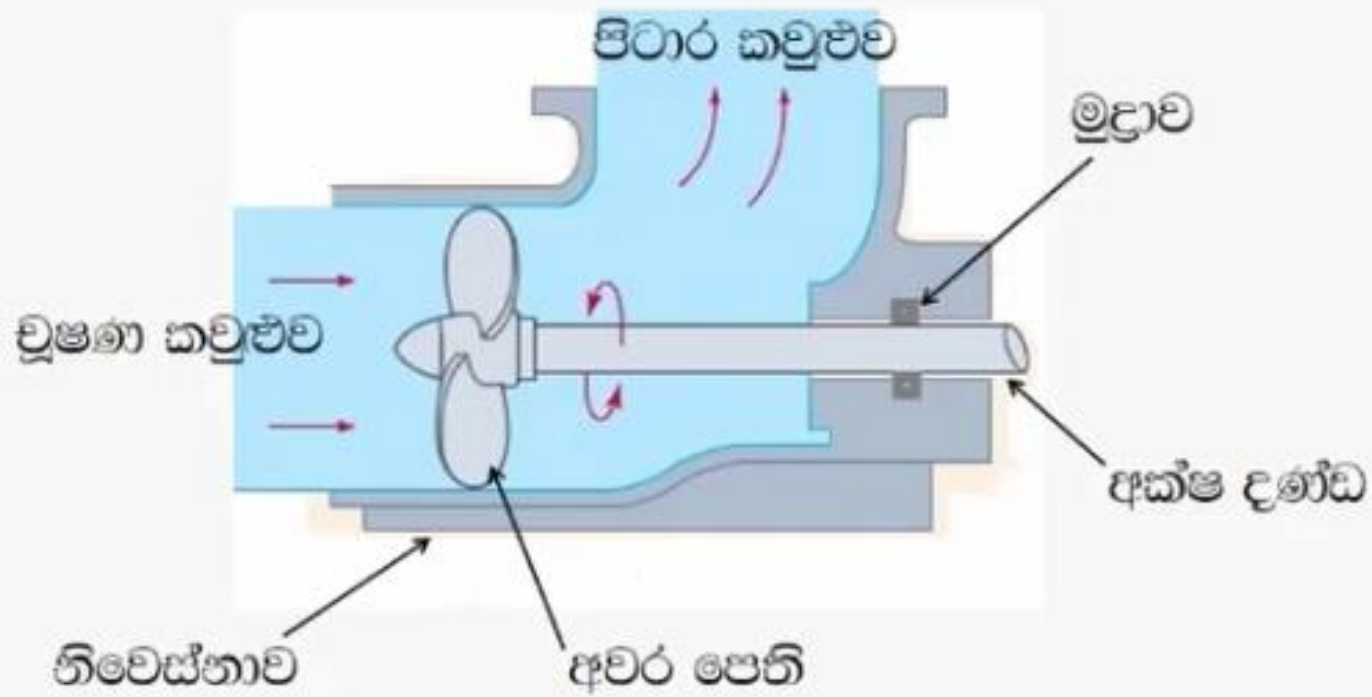
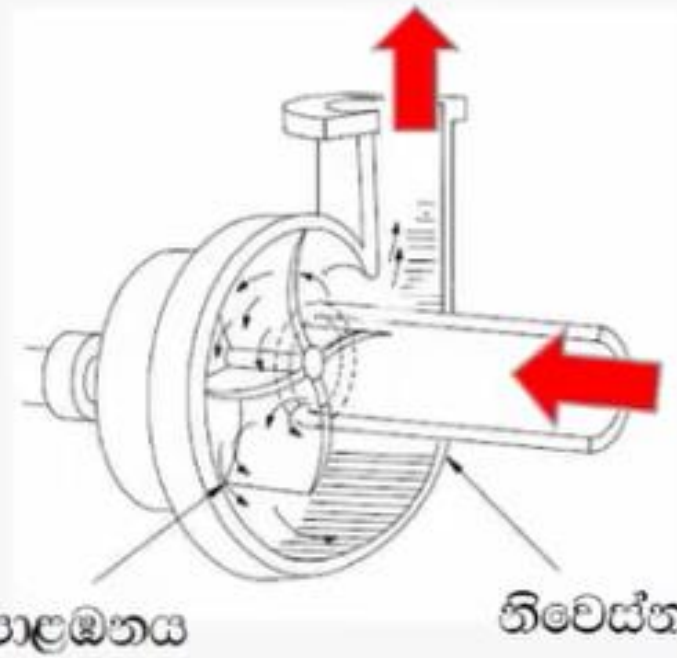



Inlet

අක්ෂීය වර්ගයේ පොම්පය



අරීය(කේන්ද්‍රාපසාරී) වර්ගයේ පොම්පය



පොම්ප වර්ග(ශක්ති ස්වරූපය මත)

- ධන විස්ථාපන

  තරලයට ඉහළ පීඩනයක් ලබා දෙයි
- ගතික

  තරලයට ඉහළ ප්‍රවේගයක් ලබා දෙයි

ධන විස්ථාපන පොම්ප

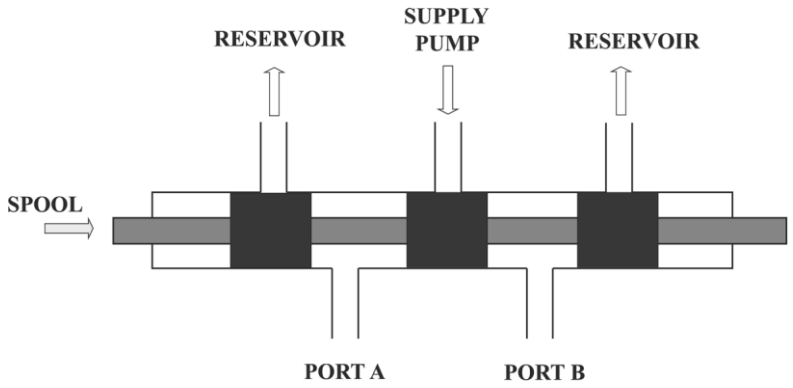
- පිස්ටන් පොම්ප
- ප්‍රාචීර පොම්ප
- ගියර පොම්ප
- ලෝබ් පොම්ප
- වේන් පොම්ප
- ඉස්කුරුප්පු පොම්ප

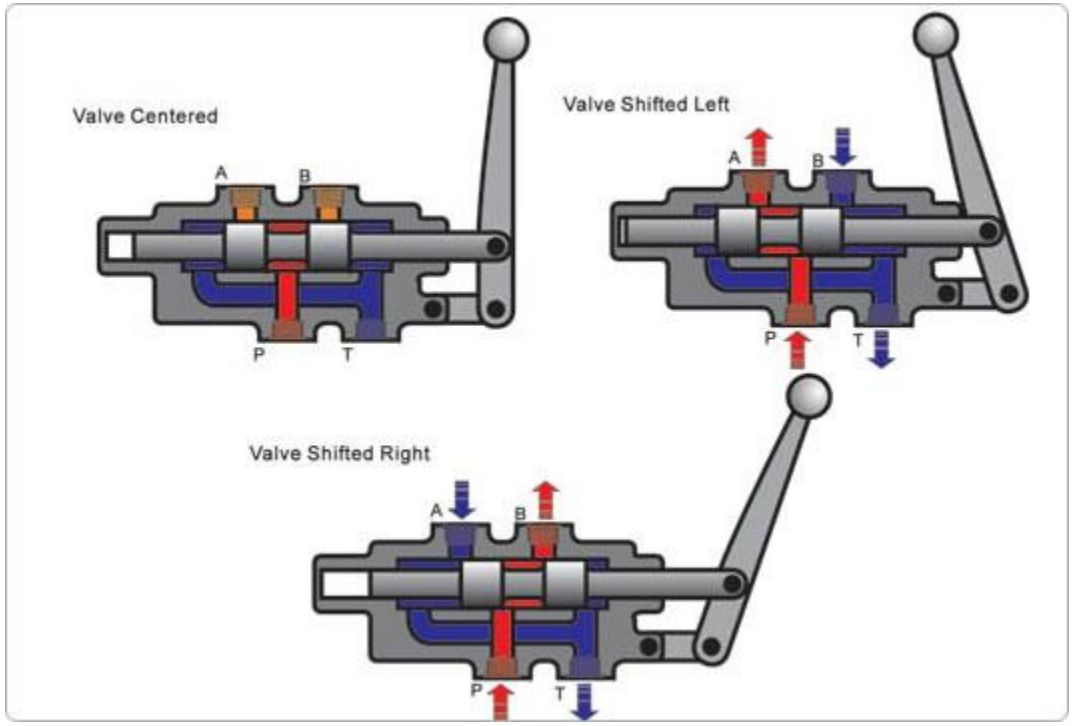
ගතික පොම්ප

- අක්ෂීය පොම්ප
- අරීය (කේන්ද්‍රාපසාරී) පොම්ප

Spool Valve

Controls direction of flow of fluid in a hydraulic system to cause the different parts of the system to function.





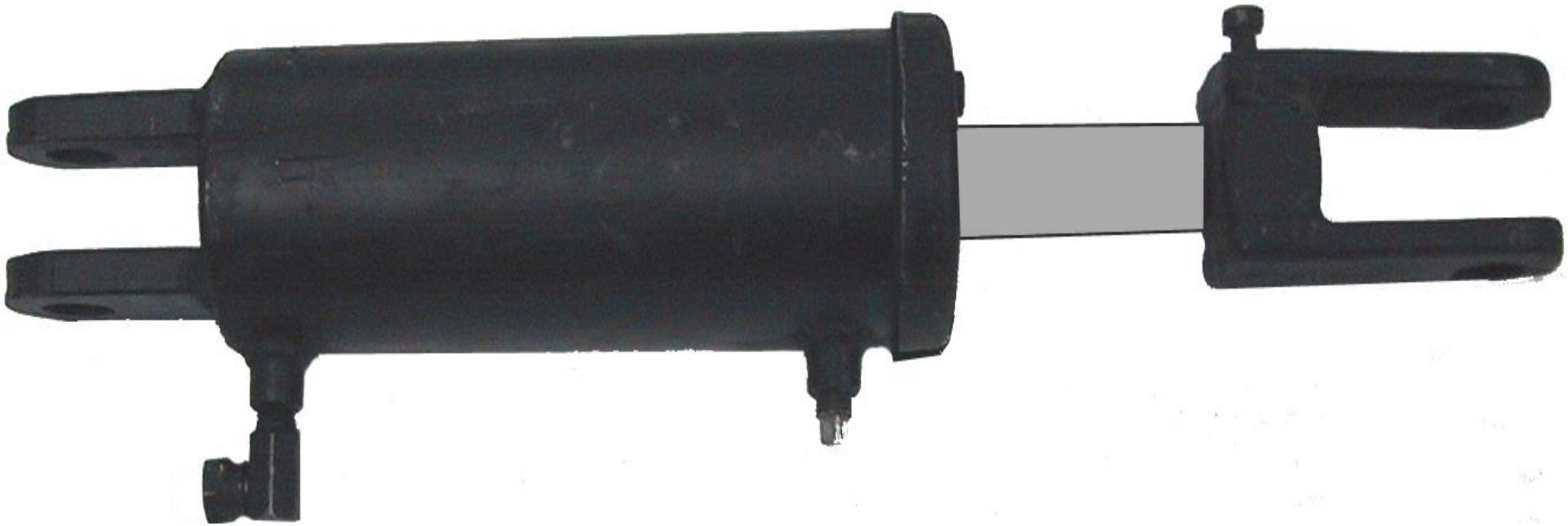
Hydraulic Motor

Receives power from moving fluid to transfer hydraulic power to mechanical rotating force.

Cylinder/Actuator

Piece of equipment that transfers hydraulic power into mechanical movement in one or two directions only.

Hydraulic Cylinder



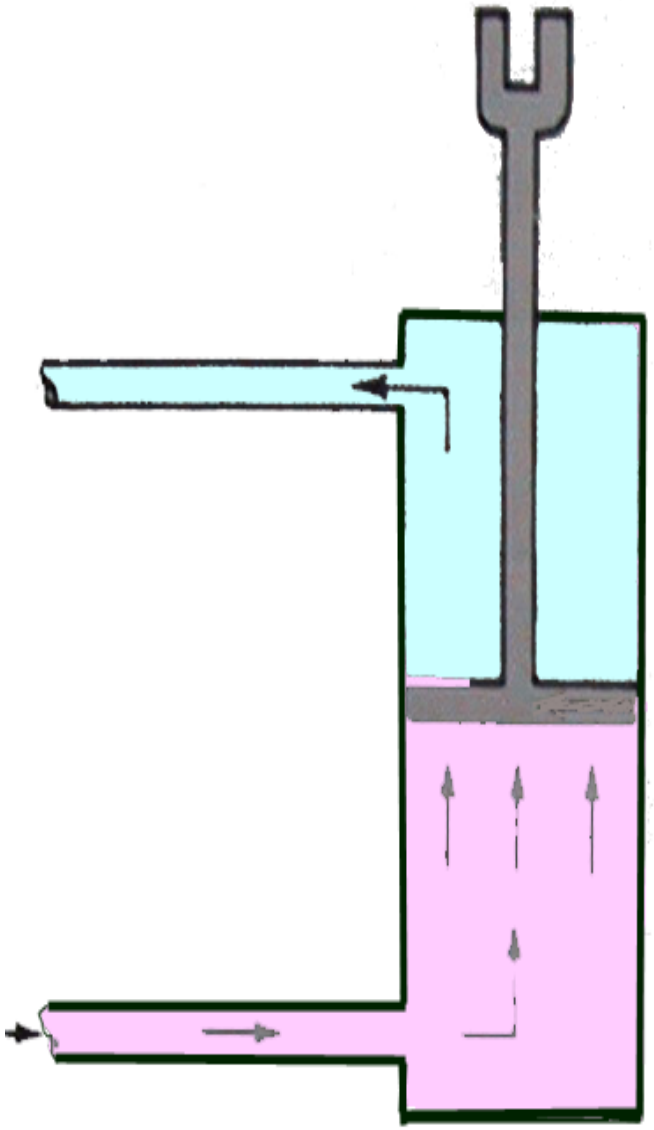
Single-acting

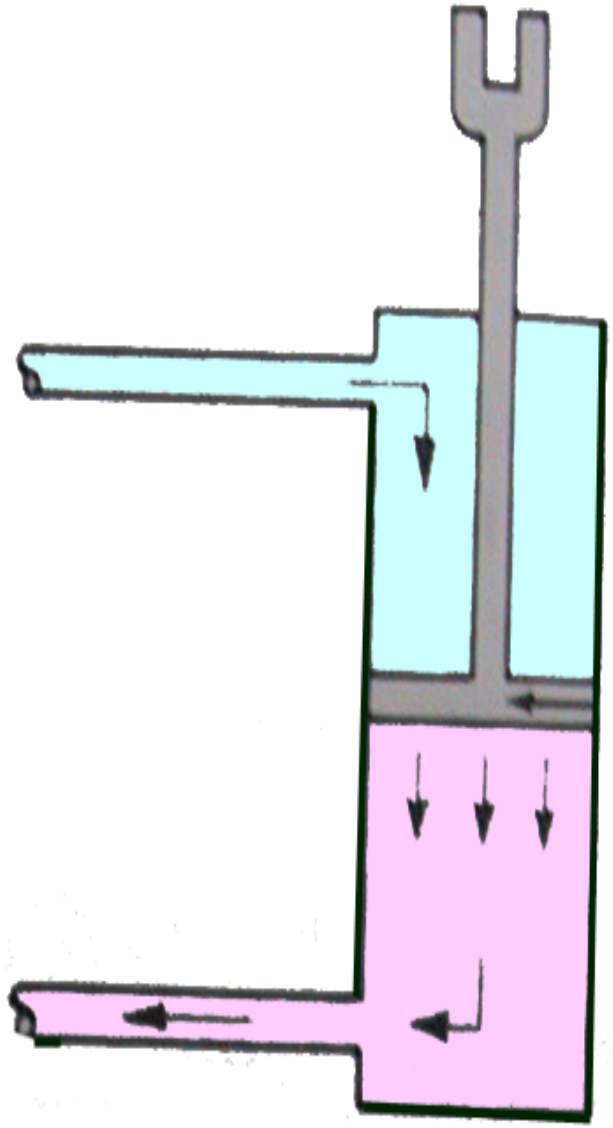
Refers to a hydraulic cylinder that works in one direction only.

Double-acting

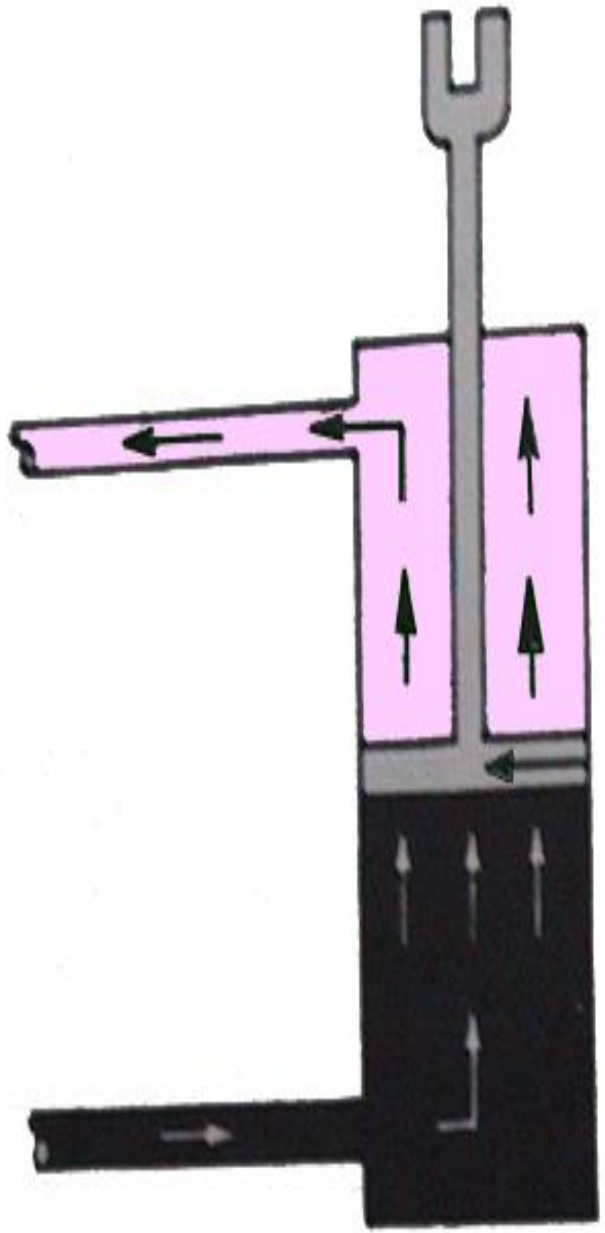
Refers to a hydraulic cylinder that pushes and pulls.

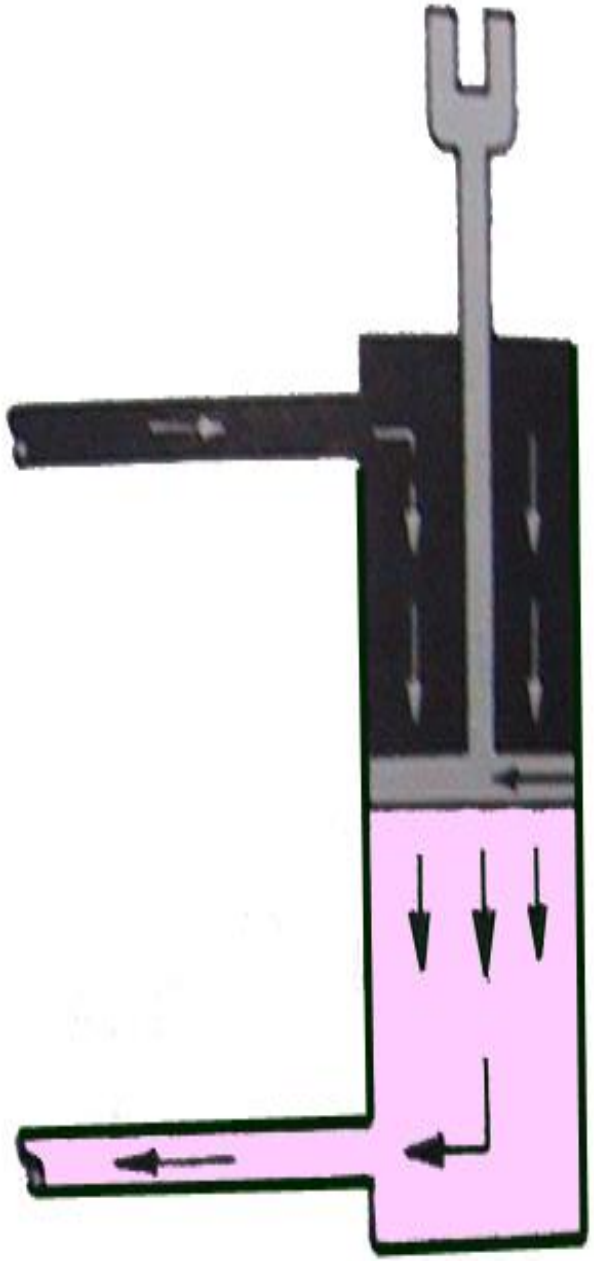
Single-acting cylinder

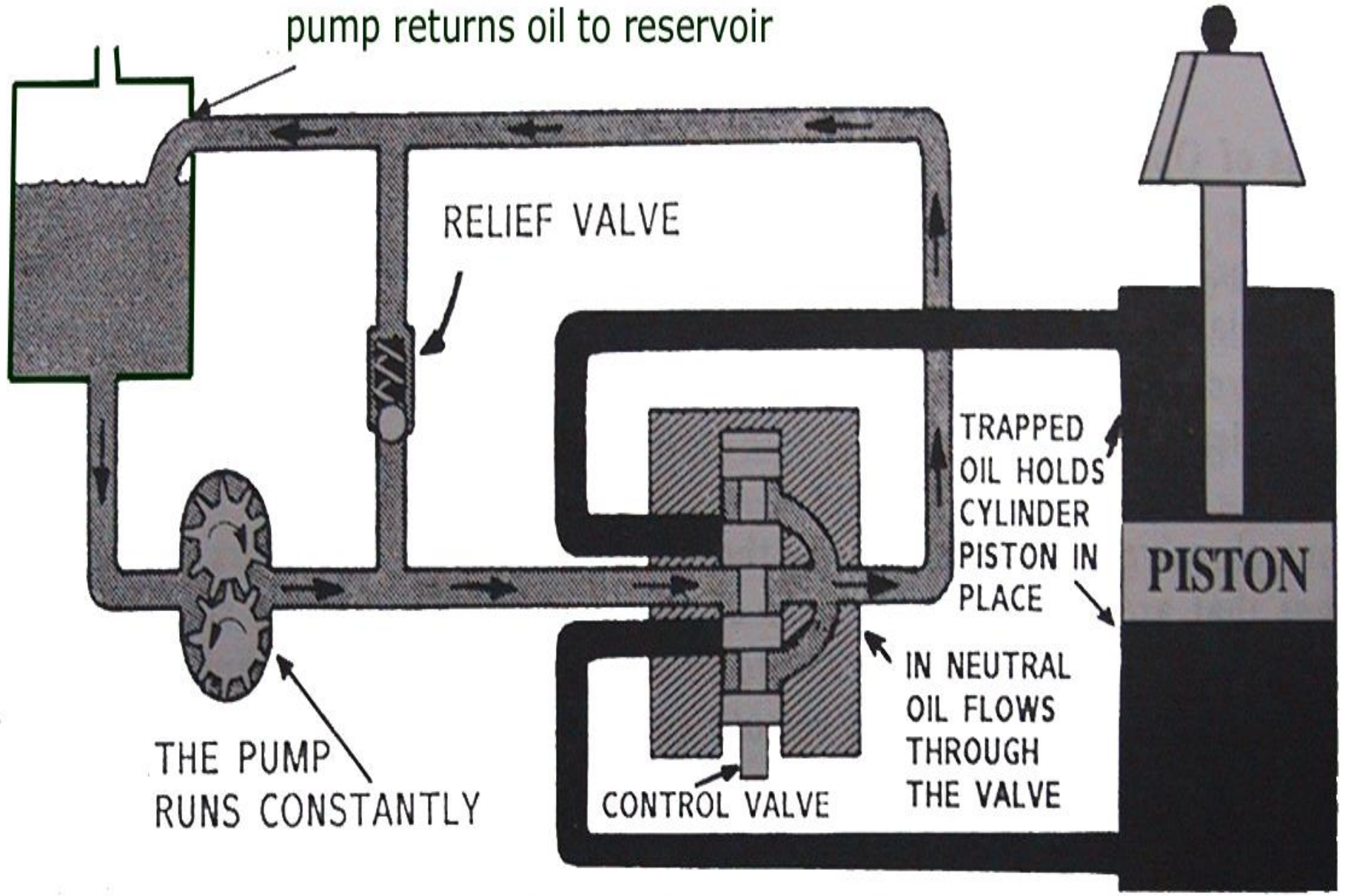




Double-acting
Cylinder







Open-Center System in Neutral