Unit-5

Industrial hydraulics

hydraulic → Greek work → means water (hydro & aulics → means pipe. hydraulics means water flow through pipe. Today we are considering this term for all fluids

Advantages of Hydraulics:-

① Transmission of large forces using small components
② Precise positioning ③ Smooth operation & reversal ④ Good control

Disadvantages ① Pollution of environment by waste oil ② Sensitivity to dirt ③ Danger with excess pressure ④ Temp. dependence (viscosity change).

Applications of Hydraulics:-

① earth moving machines such as excavators ② Cranes ③ boats
④ Ram of extrusion presses ⑤ Automated production lines
⑥ Aeroplane controls ⑦ Machine tools.

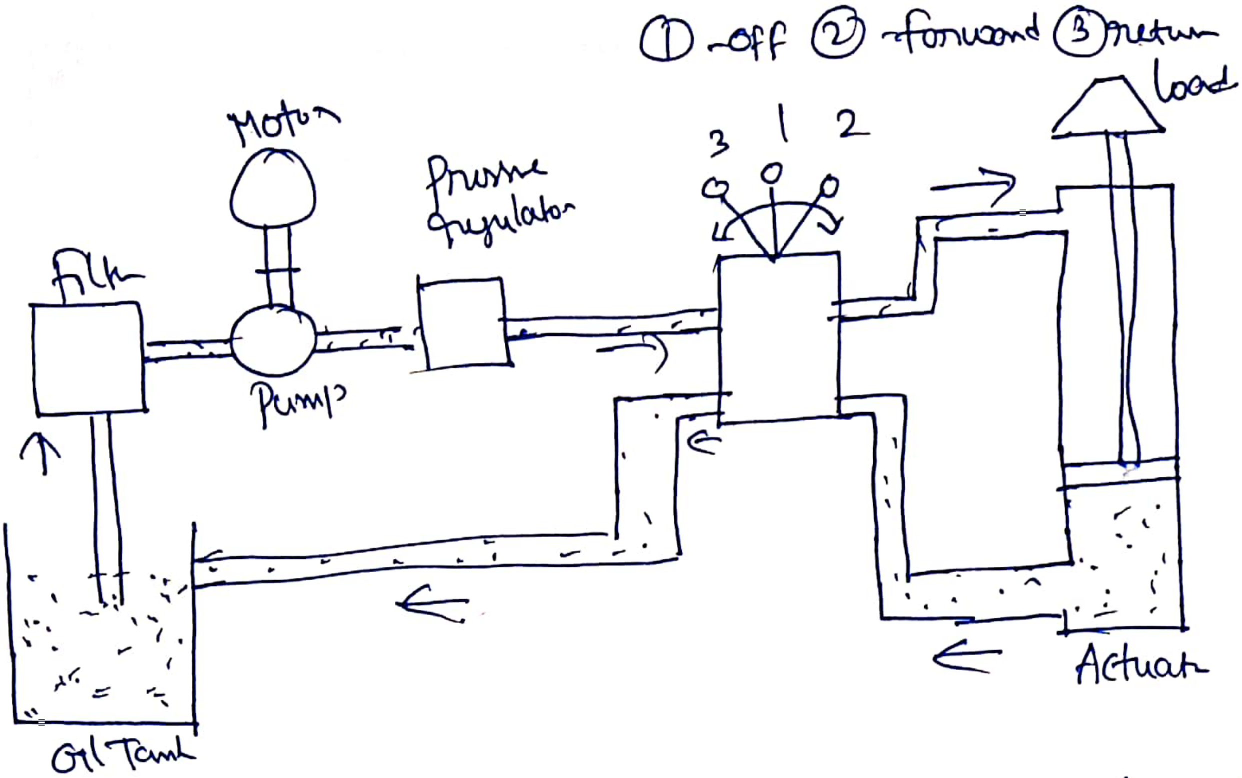
Basic Components of hydraulic Circuit:-

In hydraulic circuits all the elements can be divided into 3 categories viz. driving elements, controlling elements, energy consuming members

Driving elements consists of pumps / compressors, filters, regulators pressure gauges, service units, pressure relief valves etc

Controlling elements comprises all types of valves.

Hydraulic & Pneumatic actuators comes under energy consuming members



① Hydraulic actuator is a device used to convert the fluid power into mechanical power to do useful work.

② Pump is used to force the fluid from the reservoir to rest of the hydraulic circuit

Hydraulic oil:- This is important component in hydraulic system. It is important to use a clean high quality fluid in order to achieve efficient hydraulic system operation.

Functions of Hydraulic fluids:-

① Power Transmission ② lubrication ③ Sealing ④ Cooling

Seal between low pressure & high pressure side of valve

Characteristics of a good hydraulic fluid:-

① Viscosity:- measure of a hydraulic fluid's resistance to flow.

oil is too thin → low viscosity → does not seal sufficiently · leads to leakage and wear of parts

high " → difficult to pump reduces operating efficiency

(ii) Compressibility, amount of volume reduction due to Pressure

(iii) Weare resistance

(iv) oxidation Stability

(v) Thermal Stabilit

(vi) filterability

(vii) Rust and Corrosion

(viii) Hydraulic Stability.

Hydraulic Pumps:- In any fluid Power System The Power is transmitted from The Source to a Certain Point with The aid of pressurized fluid, The device That generates The required hydraulic pressure is Known as The hydraulic pump. when The pump is driven by Prime movers a Partial vaccum is Created at inlet Side which is filled up with The hydraulic fluid due to atmospheric pressure acting on The fluid in The reservoir.

Pump Parameter:- ① flow rate ② volumetric efficiency $\frac{\text{Actual output}}{\text{Theoretical output}}$ ③ overall efficiency $\left(\frac{\text{Actual fluid horse power required}}{\text{Pump input horse power given}}\right)$

classification of Pumps:-

- Pumps
  - Positive displacement Pumps
    - Rotary Pumps
      - Gear Pump
      - Lobe pump
    - Reciprocating Pumps
      - Piston Pump
      - Diaphram Pump
  - Dynamic Pumps
    - Centrifugal Pump
      - Axial Pump

Control valves: Valves are used in hydraulic System to Control the operation of actuators. Valves regulate pressure by Creating Special pressure Conditions.

Classification of Control valves:

(1) Directional Control Valves (2) Flow Control valve (3) Pressure Control valve
(4) Check valve.

Pressure relief Valves: It's function is to Set the maximum Pressure in the hydraulic System. The Pressure Can rise in a hydraulic System if,

(1) The flow rate from the Pump is larger than the flow rate through the actuator.

(2) The Volume of a closed System is reduced (3) The load of the actuator rises (4) The hydraulic resistance on the System rises

Relief Valves are used to Control and regulate the pressure in a hydraulic System.

(1) Direct-acting relief valve (2) Pilot operated relief Valve.

Module 5: Hydraulic Systems

Lecture 1

Introduction

1. Introduction

The controlled movement of parts or a controlled application of force is a common requirement in the industries. These operations are performed mainly by using electrical machines or diesel, petrol and steam engines as a prime mover. These prime movers can provide various movements to the objects by using some mechanical attachments like screw jack, lever, rack and pinions etc. However, these are not the only prime movers. The enclosed fluids (liquids and gases) can also be used as prime movers to provide controlled motion and force to the objects or substances. The specially designed enclosed fluid systems can provide both linear as well as rotary motion. The high magnitude controlled force can also be applied by using these systems. This kind of enclosed fluid based systems using pressurized incompressible liquids as transmission media are called as hydraulic systems. The hydraulic system works on the principle of Pascal's law which says that the pressure in an enclosed fluid is uniform in all the directions. The Pascal's law is illustrated in figure 5.1.1. The force given by fluid is given by the multiplication of pressure and area of cross section. As the pressure is same in all the direction, the smaller piston feels a smaller force and a large piston feels a large force. Therefore, a large force can be generated with smaller force input by using hydraulic systems.

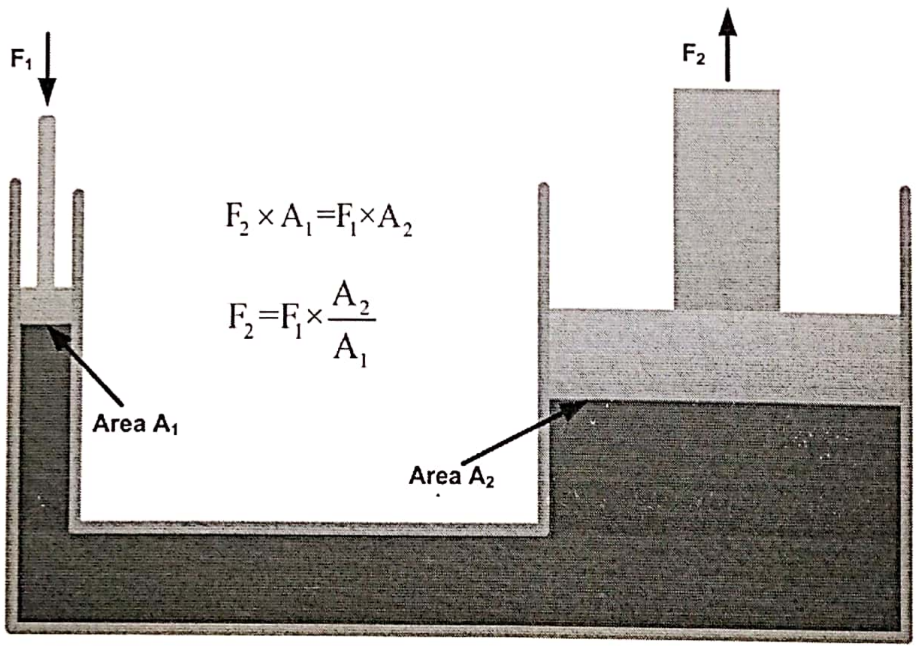


Figure 5.1.1 Principle of hydraulic system

The hydraulic systems consists a number of parts for its proper functioning. These include storage tank, filter, hydraulic pump, pressure regulator, control valve, hydraulic cylinder, piston and leak proof fluid flow pipelines. The schematic of a simple hydraulic system is shown in figure 5.1.2. It consists of:

- a movable piston connected to the output shaft in an enclosed cylinder
- storage tank
- filter
- electric pump
- pressure regulator
- control valve
- leak proof closed loop piping.

The output shaft transfers the motion or force however all other parts help to control the system. The storage/fluid tank is a reservoir for the liquid used as a transmission media. The liquid used is generally high density incompressible oil. It is filtered to remove dust or any other unwanted particles and then pumped by the hydraulic pump. The capacity of pump depends on the hydraulic system design. These pumps generally deliver constant volume in each revolution of the pump shaft. Therefore, the fluid pressure can increase indefinitely at the dead end of the piston until the system fails. The pressure regulator is used to avoid such circumstances which redirect the excess fluid back to the storage tank. The movement of piston is controlled by changing liquid flow from port A and port B. The cylinder movement is controlled by using control valve which directs the fluid flow. The fluid pressure line is connected to the port B to raise the piston and it is connected to port A to lower down the piston. The valve can also stop the fluid flow in any of the port. The leak proof piping is also important due to safety, environmental hazards and economical aspects. Some accessories such as flow control system, travel limit control, electric motor starter and overload protection may also be used in the hydraulic systems which are not shown in figure 5.1.2.

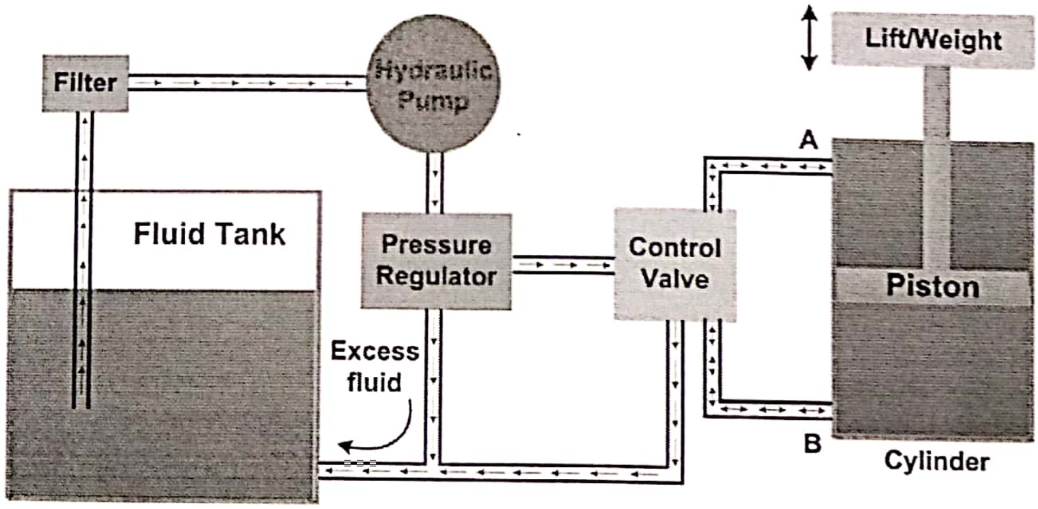


Figure 5.1.2 Schematic of hydraulic system

2. Applications of hydraulic systems

The hydraulic systems are mainly used for precise control of larger forces. The main applications of hydraulic system can be classified in five categories:

2.1 **Industrial:** Plastic processing machineries, steel making and primary metal extraction applications, automated production lines, machine tool industries, paper industries, loaders, crushes, textile machineries, R & D equipment and robotic systems etc.

2.2 **Mobile hydraulics:** Tractors, irrigation system, earthmoving equipment, material handling equipment, commercial vehicles, tunnel boring equipment, rail equipment, building and construction machineries and drilling rigs etc.

2.3 **Automobiles:** It is used in the systems like breaks, shock absorbers, steering system, wind shield, lift and cleaning etc.

2.4 **Marine applications:** It mostly covers ocean going vessels, fishing boats and navel equipment.

2.5 **Aerospace equipment:** There are equipment and systems used for rudder control, landing gear, breaks, flight control and transmission etc. which are used in airplanes, rockets and spaceships.

3. Hydraulic Pump

The combined pumping and driving motor unit is known as hydraulic pump. The hydraulic pump takes hydraulic fluid (mostly some oil) from the storage tank and delivers it to the rest of the hydraulic circuit. In general, the speed of pump is constant and the pump delivers an equal volume of oil in each revolution. The amount and direction of fluid flow is controlled by some external mechanisms. In some cases, the hydraulic pump itself is operated by a servo controlled motor but it makes the system complex. The hydraulic pumps are characterized by its flow rate capacity, power consumption, drive speed, pressure delivered at the outlet and efficiency of the pump. The pumps are not 100% efficient. The efficiency of a pump can be specified by two ways. One is the volumetric efficiency which is the ratio of actual volume of fluid delivered to the maximum theoretical volume possible. Second is power efficiency which is the ratio of output hydraulic power to the input mechanical/electrical power. The typical efficiency of pumps varies from 90-98%.

The hydraulic pumps can be of two types:

- centrifugal pump
- reciprocating pump

Centrifugal pump uses rotational kinetic energy to deliver the fluid. The rotational energy typically comes from an engine or electric motor. The fluid enters the pump impeller along or near to the rotating axis, accelerates in the propeller and flung out to the periphery by centrifugal force as shown in figure 5.1.3. In centrifugal pump the delivery is not constant and varies according to the outlet pressure. These pumps are not suitable for high pressure applications and are generally used for low-pressure and high-volume flow applications. The maximum pressure capacity is limited to 20-30 bars and the specific speed ranges from 500 to 10000. Most of the centrifugal pumps are not self-priming and the pump casing needs to be filled with liquid before the pump is started.

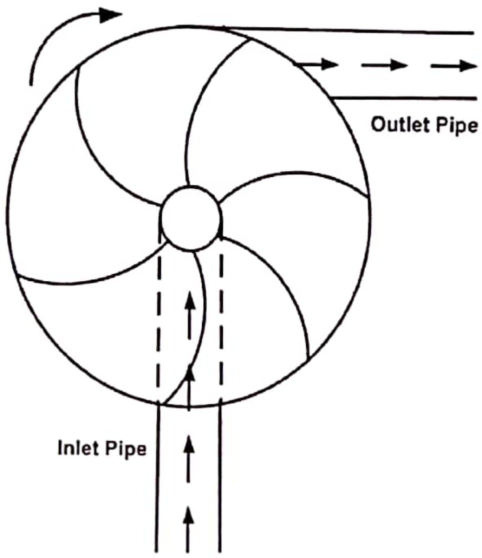


Figure 5.1.3 Centrifugal pump

The reciprocating pump is a positive plunger pump. It is also known as positive displacement pump or piston pump. It is often used where relatively small quantity is to be handled and the delivery pressure is quite large. The construction of these pumps is similar to the four stroke engine as shown in figure 5.1.4. The crank is driven by some external rotating motor. The piston of pump reciprocates due to crank rotation. The piston moves down in one half of crank rotation, the inlet valve opens and fluid enters into the cylinder. In second half crank rotation the piston moves up, the outlet valve opens and the fluid moves out from the outlet. At a time, only one valve is opened and another is closed so there is no fluid leakage. Depending on the area of cylinder the pump delivers constant volume of fluid in each cycle independent to the pressure at the output port.

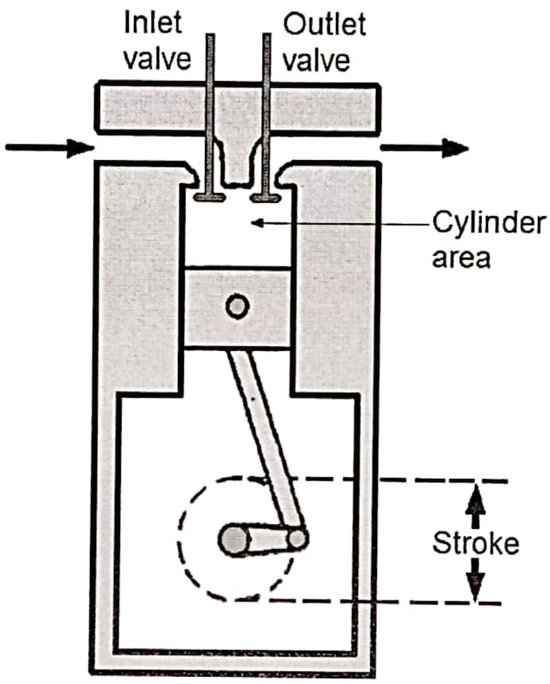


Figure 5.1.4 Reciprocating or positive displacement pump

4. Pump Lift

In general, the pump is placed over the fluid storage tank as shown in figure 5.1.5. The pump creates a negative pressure at the inlet which causes fluid to be pushed up in the inlet pipe by atmospheric pressure. It results in the fluid lift in the pump suction. The maximum pump lift can be determined by atmospheric pressure and is given by pressure head as given below:

Pressure Head, $P = \rho g h$

(5.1.1)

Theoretically, a pump lift of 8 m is possible but it is always lesser due to undesirable effects such as cavitation. The cavitation is the formation of vapor cavities in a liquid. The cavities can be small liquid-free zones ("bubbles" or "voids") formed due to partial vaporization of fluid (liquid). These are usually generated when a liquid is subjected to rapid changes of pressure and the pressure is relatively low. At higher pressure, the voids implode and can generate an intense shockwave. Therefore, the cavitation should always be avoided. The cavitation can be reduced by maintaining lower flow velocity at the inlet and therefore the inlet pipes have larger diameter than the outlet pipes in a pump. The pump lift should be as small as possible to decrease the cavitation and to increase the efficiency of the pump.

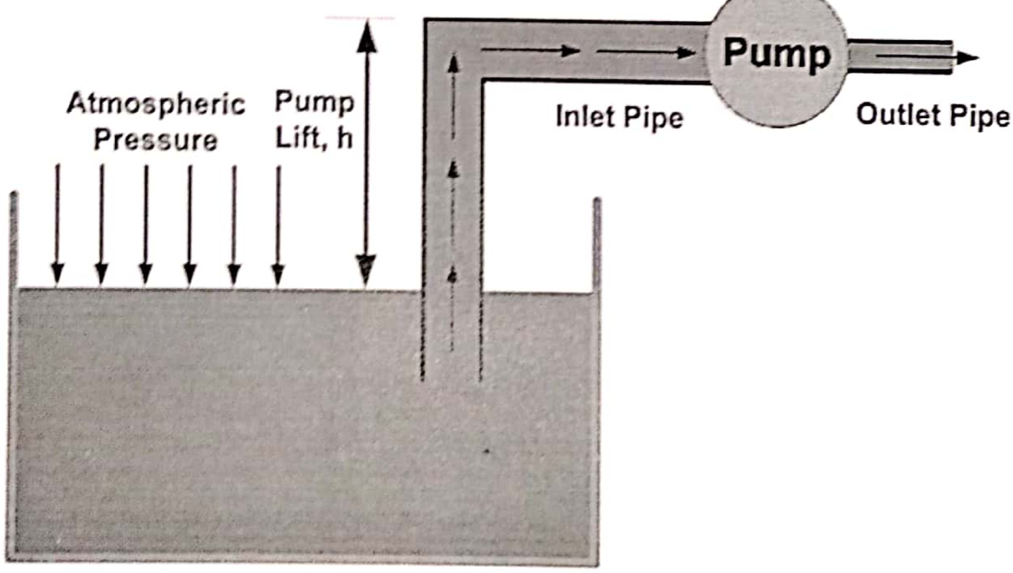


Figure 5.1.5 Pump lift