MODULE 1: INTRODUCTION TO FLUID POWER SYSTEMS

Fluid power system: components, advantages and applications. Transmission of power at static and dynamic states. Pascal's law and its applications.

Fluids for hydraulic system: types, properties, and selection. Additives, effect of temperature and pressure on hydraulic fluid. Seals, sealing materials, compatibility of seal with fluids. Types of pipes, hoses, and quick acting couplings. Pressure drop in hoses/pipes. Fluid conditioning through filters, strainers, sources of contamination and contamination control, heat exchangers.

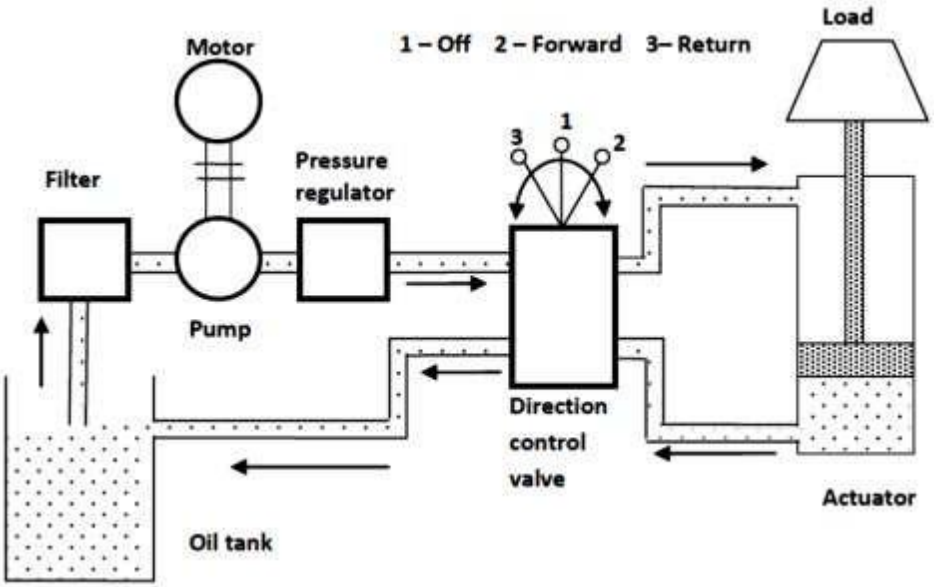
FLUID POWER SYSTEM

Fluid Power is the technology that deals with the generation, control, and transmission of power, using pressurized fluids. Fluid power is called ***hydraulics*** when the fluid is a liquid and is called ***pneumatics*** when the fluid is a gas.

Hydraulic systems use liquids such as petroleum oils, synthetic oils, and water. Pneumatic systems use air as the gas medium because air is very abundant and can be readily exhausted into the atmosphere after completing its assigned task.

COMPONENTS OF A FLUID POWER SYSTEM:

Hydraulic System:



There are six basic components required in a hydraulic system:

1) A tank (reservoir) to hold the hydraulic oil.

2) A pump to force the oil through the system.

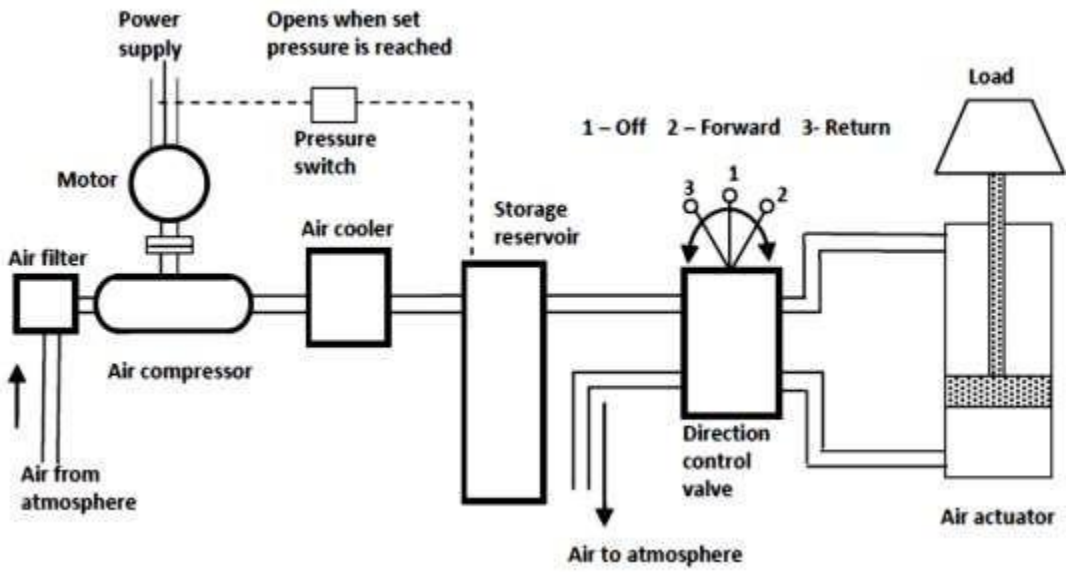
3) An electric motor or other power source to drive the pump.

4) Valves to control oil direction, pressure, and flowrate.

5) An actuator to convert the pressure of the oil into mechanical force to do the useful work.

6) Piping to carry the oil from one location to the other.

Pneumatic System:



Pneumatic systems have components that are similar to those used in hydraulic systems.

1) An air tank to store a given volume of compressed air.

2) A compressor to compress the air that comes directly from the atmosphere.

3) An electric motor or other prime mover to drive the compressor.

4) Valves to control air direction, pressure and flowrate.

5) Actuators, which are similar in operation to hydraulic actuators.

6) Piping to carry the pressurized air from one location to another.

ADVANTAGES OF FLUID POWER SYSTEM:

The advantages of a fluid power system are as follows:

1) Fluid power systems are simple, easy to operate and can be controlled accurately: Fluid power gives flexibility to equipment without requiring a complex mechanism. Using fluid power, we can start, stop, accelerate, decelerate, reverse or position large forces/components with great accuracy using simple levers and push buttons.

2) Multiplication and variation of forces: Linear or rotary force can be multiplied by a fraction of a kilogram to several hundreds of tons.

3) Multifunction control: A single hydraulic pump or air compressor can provide power and control for numerous machines using valve manifolds and distribution systems.

4) Low-speed torque: Unlike electric motors, air or hydraulic motors can produce a large amount of torque while operating at low speeds.

5) Constant force or torque: Fluid power systems can deliver constant torque or force regardless of speed changes.

6) Economical: Not only reduction in required manpower but also the production or elimination of operator fatigue, as a production factor, is an important element in the use of fluid power.

7) Low weight to power ratio: The hydraulic system has a low weight to power ratio compared to electromechanical systems. Fluid power systems are compact.

8) Fluid power systems can be used where safety is of vital importance: Safety is of vital importance in air and space travel, in the production and operation of motor vehicles, in mining and manufacture of delicate products.

APPLICATIONS OF FLUID POWER:

1) Agriculture: Tractors and farm equipments like ploughs, movers, chemical sprayers, fertilizer spreaders.

2) Aviation: Fluid power equipments like landing wheels on aeroplane and helicopter, aircraft trolleys, aircraft engine test beds.

3) Building Industry: For metering and mixing of concrete ingredients from hopper.

4) Construction Equipment: Earthmoving equipments like excavators, bucket loaders, dozers, crawlers, and road graders.

5) Defence: Missile-launch systems and Navigation controls

6) Entertainment: Amusement park entertainment rides like roller coasters

7) Fabrication Industry: Hand tools like pneumatic drills, grinders, bores, riveting machines, nut runners

8) Food and Beverage: All types of food processing equipment, wrapping, bottling

9) Foundry: Full and semi-automatic moulding machines, tilting of furnaces, die casting machines

10) Material Handling: Jacks, Hosts, Cranes, Forklift, Conveyor system

TRANSMISSION OF POWER AT STATIC AND DYNAMIC STATES:

A hydrostatic system uses fluid pressure to transmit power. Hydrostatics deals with the mechanics of still fluids and uses the theory of equilibrium conditions in fluid. The system creates high pressure, and through a transmission line and a control element, this pressure drives an actuator (linear or rotational). The pump used in hydrostatic systems is a positive displacement pump. An example of pure hydrostatics is the transfer of force in hydraulics.

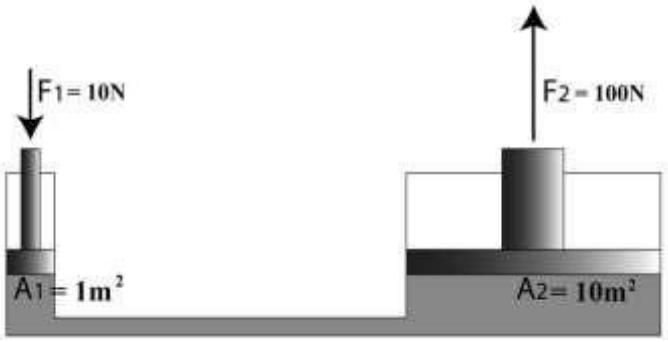
Hydrodynamic systems use fluid motion to transmit power. Power is transmitted by the kinetic energy of the fluid. Hydrodynamics deals with the mechanics of moving fluid and uses flow theory. The pump used in hydrodynamic systems is a non-positive displacement pump. An example of pure hydrodynamics is the conversion of flow energy in turbines in hydroelectric power plants.

In oil hydraulics, we deal mostly with the fluid working in a confined system, that is, a hydrostatic system.

PASCAL'S LAW (MULTIPLICATION OF FORCE):

Pascal's law reveals the basic principle of how fluid power systems perform useful work. This law can be stated as follows:

Pressure applied to a confined fluid is transmitted undiminished in all directions throughout the fluid and acts perpendicular to the surface in contact with the fluid.



The above figure shows how Pascal's law can be applied to produce a useful amplified output force. Consider an input force of 10N is applied to a 1-m^2 area piston. This develops a 10N/m^2 pressure throughout the oil within the housing. This 10N/m^2 pressure acts on a 10-m^2 area piston producing a 100N output force. This output force performs useful work as it lifts the 100N weight.

From Pascal's law we know that, $P_1 = P_2$ i.e., $\frac{F_1}{A_1} = \frac{F_2}{A_2}$

$$\frac{10}{1} = \frac{F_2}{10} \qquad \therefore F_2 = 100\text{N}$$

FLUIDS FOR HYDRAULIC SYSTEM:

The most important material in a hydraulic system is the working fluid itself. Hydraulic fluid characteristics have a crucial effect on equipment performance and life. It is important to use a clean, high-quality fluid in order to achieve efficient hydraulic system operation.

DIFFERENT TYPES OF HYDRAULIC FLUIDS:

1) Water: The least expensive hydraulic fluid is water. Water is treated with chemicals before being used in a fluid power system. This treatment removes undesirable contaminates.

2) Petroleum Oils: These are the most common among the hydraulic fluids which are used in a wide range of hydraulic applications. The characteristic of petroleum based hydraulic oils are controlled by the type of crude oil used.