

Lecture 1

INTRODUCTION TO HYDRAULICS AND PNEUMATICS

Learning Objectives

Upon completion of this chapter, the student should be able to:

- Explain the meaning of fluid power.
- List the various applications of fluid power.
- Differentiate between fluid power and transport systems.
- List the advantages and disadvantages of fluid power.
- Explain the industrial applications of fluid power.
- List the basic components of the fluid power.
- List the basic components of the pneumatic systems.
- Differentiate between electrical, pneumatic and fluid power systems.
- Appreciate the future of fluid power in India.

1.1 Introduction

In the industry we use three methods for transmitting power from one point to another. Mechanical transmission is through shafts, gears, chains, belts, etc. Electrical transmission is through wires, transformers, etc. Fluid power is through liquids or gas in a confined space. In this chapter, we shall discuss a structure of hydraulic systems and pneumatic systems. We will also discuss the advantages and disadvantages and compare hydraulic, pneumatic, electrical and mechanical systems.

1.2 Fluid Power and Its Scope

Fluid power is the technology that deals with the generation, control and transmission of forces and movement of mechanical element or system with the use of pressurized fluids in a confined system. Both liquids and gases are considered fluids. Fluid power system includes a hydraulic system (*hydra* meaning water in Greek) and a pneumatic system (*pneuma* meaning air in Greek). Oil hydraulic employs pressurized liquid petroleum oils and synthetic oils, and pneumatic employs compressed air that is released to the atmosphere after performing the work.

Perhaps it would be in order that we clarify our thinking on one point. By the term “fluid” we refer to air or oil, for it has been shown that water has certain drawbacks in the transmission of hydraulic power in machine operation and control. Commercially, pure water contains various chemicals (some deliberately included) and also foreign matter, and unless special precautions are taken when it is used, it is nearly impossible to maintain valves and working surfaces in satisfactory condition. In the cases where the hydraulic system is closed (i.e., the one with a self-contained unit that serves one machine or one small group of machines), oil is commonly used, thus providing, in addition to power transmission, benefits of lubrication not afforded by water as well as increased life and efficiency of packings and valves. It should be mentioned that in some special cases, soluble oil diluted with water is used for safety reasons. The application of fluid power is limited only by the ingenuity of the designer, production engineer or plant engineer. If the application pertains to lifting, pushing, pulling, clamping, tilting, forcing, pressing or any other straight line (and many rotary) motions, it is possible that fluid power will meet the requirement.

Fluid power applications can be classified into two major segments:

Stationary hydraulics: Stationary hydraulic systems remain firmly fixed in one position. The characteristic feature of stationary hydraulics is that valves are mainly solenoid operated. The applications of stationary hydraulics are as follows:

Production and assembly of vehicles of all types.

- Machine tools and transfer lines.
- Lifting and conveying devices.
- Metal-forming presses.
- Plastic machinery such as injection-molding machines.
- Rolling machines.
- Lifts.
- Food processing machinery.
- Automatic handling equipment and robots.

Mobile hydraulics: Mobile hydraulic systems move on wheels or tracks such as a tower crane or excavator truck to operate in many different locations or while moving. A characteristic feature of mobile hydraulics is that the valves are frequently manually operated. The applications of mobile hydraulics are as follows:

- Automobiles, tractors, aeroplanes, missile, boats, etc.
- Construction machinery.
- Tippers, excavators and elevating platforms.
- Lifting and conveying devices.
- Agricultural machinery.

Hydraulics and pneumatics have almost unlimited application in the production of goods and services in nearly all sectors of the country. Several industries are dependent on the capabilities that fluid power affords. Table 1.1 summarizes few applications of fluid power.

Table 1.1 More applications of fluid power

Agriculture	Tractors; farm equipment such as mowers, ploughs, chemical and water sprayers, fertilizer spreaders, harvesters
Automation	Automated transfer lines, robotics
Automobiles	Power steering, power brakes, suspension systems, hydrostatic transmission
Aviation	Fluid power equipment such as landing wheels in aircraft. Helicopters, aircraft trolleys, aircraft test beds, luggage loading and unloading systems, ailerons, aircraft servicing, flight simulators
Construction industry/equipment	For metering and mixing of concrete rudders, excavators, lifts, bucket loaders, crawlers, post-hole diggers, road graders, road cleaners, road maintenance vehicles, tippers
Defense	Missile-launching systems, navigation controls
Entertainment	Amusement park entertainment rides such as roller coasters
Fabrication industry	Hand tools such as pneumatic drills, grinders, borers, riveting machines, nut runners
Food and beverage	All types of food processing equipment, wrapping, bottling,
Foundry	Full and semi-automatic molding machines, tilting of furnaces, die-casting machines
Glass industry	Vacuum suction cups for handling

Hazardous gaseous areas	Hydraulic fracturing technologies: It involves pumping large volumes of water and sand into a well at high pressure to fracture shale and other tight formations, allowing hazardous oil and gas to flow into the well. However, hydraulic fracturing has serious environmental and water pollution related issues.
Instrumentation	Used to create/operate complex instruments in space rockets, gas turbines, nuclear power plants, industrial labs
Jigs and fixtures	Work holding devices, clamps, stoppers, indexers
Machine tools	Automated machine tools, numerically controlled(NC) machine tools
Materials handling	Jacks, hoists, cranes, forklifts, conveyor systems
Medical	Medical equipment such as breathing assistors, heart assist devices, cardiac compression machines, dental drives and human patient simulator
Movies	Special-effect equipment use fluid power; movies such as Jurassic park, Jaws, Anaconda, Titanic
Mining	Rock drills, excavating equipment, ore conveyors, loaders
Newspapers and periodicals	Edge trimming, stapling, pressing, bundle wrapping
Oil industry	Off-shore oil rigs
Paper and packaging	Process control systems, special-purpose machines for rolling and packing
Pharmaceuticals	Process control systems such as bottle filling, tablet placement, packaging
Plastic industry	Automatic injection molding machines, raw material feeding, jaw closing, movement of slides of blow molder

Press tools	Heavy duty presses for bulk metal formation such as sheet metal, forging, bending, punching, etc.
Printing industry	For paper feeding, packaging
Robots	Fluid power operated robots, pneumatic systems
Ships	Stabilizing systems, unloading and loading unit, gyroscopic instruments, movement of flat forms, lifters, subsea inspection equipment
Textiles	Web tensioning devices, trolleys, process controllers
Transportation	Hydraulic elevators, winches, overhead trams
Under sea	Submarines, under sea research vehicles, marine drives and control of ships
Wood working	Tree shearers, handling huge logs, feeding clamping and saw operations

The following are the two types of hydraulic systems:

1. **Fluid transport systems:** Their sole objective is the delivery of a fluid from one location to another to accomplish some useful purpose. Examples include pumping stations for pumping water to homes, cross-country gas lines, etc.
2. **Fluid power systems:** These are designed to perform work. In fluid power systems, work is obtained by pressurized fluid acting directly on a fluid cylinder or a fluid motor. A cylinder produces a force resulting in linear motion, whereas a fluid motor produces a torque resulting in rotary motion.

1.3 Classification of Fluid Power Systems

The fluid power system can be categorized as follows:

1. **Based on the control system**

- Open-loop system:** There is no feedback in the open system and performance is based on the characteristics of the individual components of the system. The open-

loop system is not accurate and error can be reduced by proper calibration and control.

- Closed-loop system:** This system uses feedback. The output of the system is fed back to a comparator by a measuring element. The comparator compares the actual output to the desired output and gives an error signal to the control element. The error is used to change the actual output and bring it closer to the desired value. A simple closed-loop system uses servo valves and an advanced system uses digital electronics.

2. Based on the type of control

- Fluid logic control:** This type of system is controlled by hydraulic oil or air. The system employs fluid logic devices such as AND, NAND, OR, NOR, etc. Two types of fluid logic systems are available:
 - (a) *Moving part logic (MPL):* These devices are miniature fluid elements using moving parts such as diaphragms, disks and poppets to implement various logic gates.
 - (b) *Fluidics:* Fluid devices contain no moving parts and depend solely on interacting fluid jets to implement various logic gates.
- Electrical control:** This type of system is controlled by electrical devices. Four basic electrical devices are used for controlling the fluid power systems: switches, relays, timers and solenoids. These devices help to control the starting, stopping, sequencing, speed, positioning, timing and reversing of actuating cylinders and fluid motors. Electrical control and fluid power work well together where remote control is essential.
- Electronic control:** This type of system is controlled by microelectronic devices. The electronic brain is used to control the fluid power muscles for doing work. This system uses the most advanced type of electronic hardware including programmable logic control (PLC) or microprocessor (µP). In the electrical control, a change in system operation results in a cumbersome process of redoing hardware connections. The difficulty is overcome by programmable electronic control. The program can be modified or a new program can be fed to meet the change of operations. A number of such programs can be stored in these devices, which makes the systems more flexible.

1.4 Hydrostatic and Hydrodynamic Systems

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. The relative spatial position of this pump is arbitrary but should not be very large due to losses (must be less than 50 m). 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. The relative spatial position of the prime mover (e.g., turbine) is fixed. 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.

1.5 History of Fluid Power

Fluid power is as old as our civilization itself. Water was used for centuries to produce power by means of water wheels and air was used to turn windmills and to propel ships. Chinese used wooden valves to control water flow through bamboo pipes in 4000 BC. Ancient Egyptians have built a masonry dam across Nile, 14 miles south to present Cairo, for the control of irrigation water by canals, sluices, brick conduits and ceramic pipes. During the Roman empire, extensive water systems using aqueducts, reservoirs and valves were constructed to carry water to cities. However, these early uses of fluid power required the movement of huge quantities of fluid because of the relatively low pressures provided by nature.

Fluid power technology actually began in 1650 with the discovery of Pascal's law. Simply stated, this law says that *pressure in a fluid at rest is transmitted undiminished equally in all directions in a confined body of fluid*. Pascal found that when he rammed a cork down into a jug completely full of wine, the bottom of the jug broke and fell out. However, in order for Pascal's law to be made effective for practical use, it was necessary to make a piston that would fit exactly. Not until over 100 years later was this accomplished. It was in 1795 that

Joseph Bramah invented the cup packing that led to the development of a workable hydraulic press. Bramah's hydraulic press consisted of a plunger pump piped to a large cylinder and a ram. This new hydraulic press found wide use in England because it provided a more effective and economical means of applying large force to industrial applications.

In 1750, Bernoulli developed his law of conservation of energy for a fluid flowing in a pipeline. Both Pascal's and Bernoulli's laws operate at the heart of all fluid power applications and are used for analytical purposes. However, it was not until the Industrial Revolution of 1850 in Great Britain that these laws were actually applied to the industry.

The first use of a large hydraulic press for foregoing work was made in 1860 by Whitworth. In the next 20 years, many attempts were made to reduce the waste and excessive maintenance costs of the original type of accumulator. In 1872, Rigg patented a three-cylinder hydraulic engine in which provision was made to change the stroke of plungers to vary its displacement without a throttle valve. In 1873, the Brotherhood three-cylinder, constant-stroke hydraulic engine was patented and was widely used for cranes, winches, etc. Both the above-mentioned engines were driven by fluid from an accumulator.

Up to this time, electrical energy was not developed to power the machines of industry. Instead, fluid power was being used to drive hydraulic equipment such as cranes, presses, shearing machines, etc. With electricity emerging dominantly in the 19th century, it was soon found superior to fluid power for transmitting power over great distances.

The modern era in fluid power began around the turn of the century. Fluid applications were made to such installations as the main armament system of USS Virginia in 1906. In these applications, a variable-speed hydrostatic transmission was installed to drive the main guns. Since that time, marine industry has applied fluid power to cargo-handling systems, controllable pitch controllers, submarine control system, aircraft elevators, aircraft- and missile-launching system and radar/sonar-driven systems. In 1926, the United States developed the first unitized, packaged hydraulic system consisting of a pump, controls and an actuator.

Today fluid power is used extensively in practically every branch of industry. The innovative use of modern technology such as electrohydraulic closed loops, microprocessors and improved materials for component construction continues to advance the performance of fluid power systems. The military requirements kept fluid power applications and developments going at a good pace. Aviation and aerospace industry provided the impetus for many advances in fluid power technology.

1.6 Advantages of a Fluid Power System

Oil hydraulics stands out as the prime moving force in machinery and equipment designed to handle medium to heavy loads. In the early stages of industrial development, mechanical linkages were used along with prime movers such as electrical motors and engines for handling loads. But the mechanical efficiency of linkages was very low and the linkages often failed under critical loading conditions. With the advent of fluid power technology and associated electronics and control, it is used in every industry now.

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. For example, in Earth-moving equipment, bucket carrying load can be raised or lowered by an operator using a lever. The landing gear of an aircraft can be retrieved to home position by the push button.
- 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. The fluid power controls can be placed at a central station so that the operator has, at all times, a complete control of the entire production line, whether it be a multiple operation machine or a group of machines. Such a setup is more or less standard in the steel mill industry.
- 4. Low-speed torque:** Unlike electric motors, air or hydraulic motors can produce a large amount of torque while operating at low speeds. Some hydraulic and pneumatic motors can even maintain torque at a very slow speed without overheating.
- 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. For example, hydraulic systems are responsible for the safety of takeoff, landing and flight of aeroplanes and space craft. Rapid advances in mining and tunneling are the results of the application of modern hydraulic and pneumatic systems.

1.7 Basic Components of a Hydraulic System

Hydraulic systems are power-transmitting assemblies employing pressurized liquid as a fluid for transmitting energy from an energy-generating source to an energy-using point to accomplish useful work. Figure 1.1 shows a simple circuit of a hydraulic system with basic components.

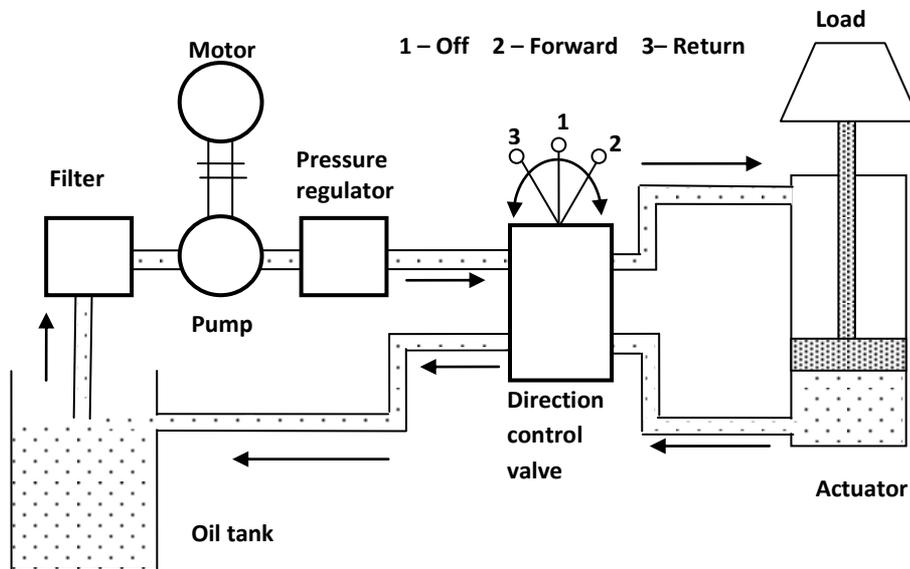


Figure 1.1 Components of a hydraulic system

Functions of the components shown in Fig. 1.1 are as follows:

1. The hydraulic actuator is a device used to convert the fluid power into mechanical power to do useful work. The actuator may be of the linear type (e.g., hydraulic cylinder) or rotary type (e.g., hydraulic motor) to provide linear or rotary motion, respectively.
2. The hydraulic pump is used to force the fluid from the reservoir to rest of the hydraulic circuit by converting mechanical energy into hydraulic energy.
3. Valves are used to control the direction, pressure and flow rate of a fluid flowing through the circuit.

4. External power supply (motor) is required to drive the pump.
5. Reservoir is used to hold the hydraulic liquid, usually hydraulic oil.
6. Piping system carries the hydraulic oil from one place to another.
7. Filters are used to remove any foreign particles so as keep the fluid system clean and efficient, as well as avoid damage to the actuator and valves.
8. Pressure regulator regulates (i.e., maintains) the required level of pressure in the hydraulic fluid.

The piping shown in Fig. 1.1 is of closed-loop type with fluid transferred from the storage tank to one side of the piston and returned back 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.

Cylinder movement is controlled by a three-position change over a control valve.

1. When the piston of the valve is changed to upper position, the pipe pressure line is connected to port A and thus the load is raised.
2. When the position of the valve is changed to lower position, the pipe pressure line is connected to port B and thus the load is lowered.
3. When the valve is at center position, it locks the fluid into the cylinder (thereby holding it in position) and dead-ends the fluid line (causing all the pump output fluid to return to tank via the pressure relief).

In industry, a machine designer conveys the design of hydraulic systems using a circuit diagram. Figure 1.2 shows the components of the hydraulic system using symbols. The working fluid, which is the hydraulic oil, is stored in a reservoir. When the electric motor is switched ON, it runs a positive displacement pump that draws hydraulic oil through a filter and delivers at high pressure. The pressurized oil passes through the regulating valve and does work on actuator. Oil from the other end of the actuator goes back to the tank via return line. To and fro motion of the cylinder is controlled using directional control valve.

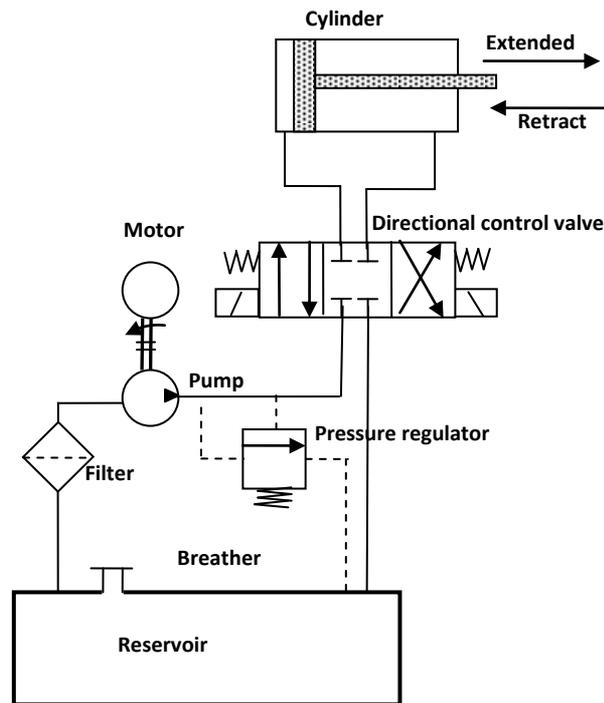


Figure 1.2 Components of a hydraulic system (shown using symbols).

The hydraulic system discussed above can be broken down into four main divisions that are analogous to the four main divisions in an electrical system.

1. The power device parallels the electrical generating station.
2. The control valves parallel the switches, resistors, timers, pressure switches, relays, etc.
3. The lines in which the fluid power flows parallel the electrical lines.
4. The fluid power motor (whether it is a rotating or a non rotating cylinder or a fluid power motor) parallels the solenoids and electrical motors.

1.8 Basic Components of a Pneumatic System

A pneumatic system carries power by employing compressed gas, generally air, as a fluid for transmitting energy from an energy-generating source to an energy-using point to accomplish useful work. Figure 1.3 shows a simple circuit of a pneumatic system with basic components.

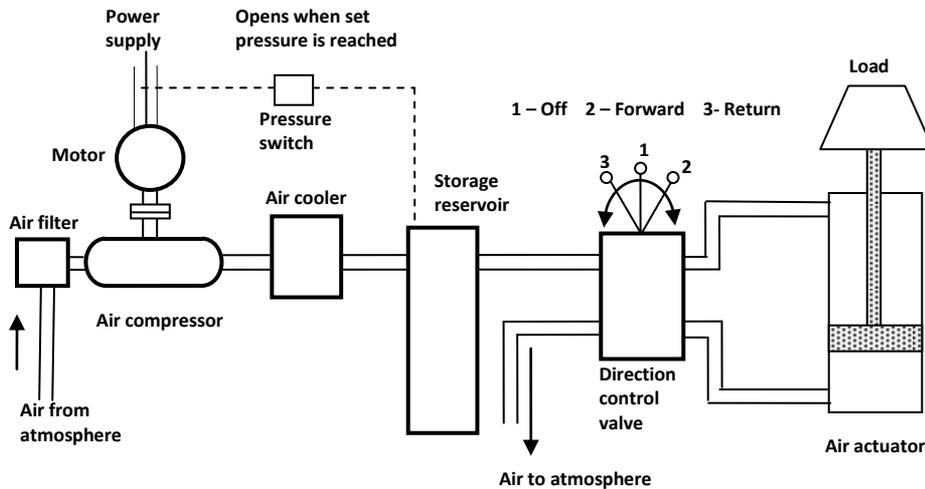


Figure 1.3 Components of a pneumatic system.

The functions of various components shown in Fig. 1.3 are as follows:

1. The pneumatic actuator converts the fluid power into mechanical power to perform useful work.
2. The compressor is used to compress the fresh air drawn from the atmosphere.
3. The storage reservoir is used to store a given volume of compressed air.
4. The valves are used to control the direction, flow rate and pressure of compressed air.
5. External power supply (motor) is used to drive the compressor.
6. The piping system carries the pressurized air from one location to another.

Air is drawn from the atmosphere through an air filter and raised to required pressure by an air compressor. As the pressure rises, the temperature also rises; hence, an air cooler is provided to cool the air with some preliminary treatment to remove the moisture. The treated pressurized air then needs to get stored to maintain the pressure. With the storage reservoir, a pressure switch is fitted to start and stop the electric motor when pressure falls and reaches the required level, respectively.

The three-position change over the valve delivering air to the cylinder operates in a way similar to its hydraulic circuit.

1.9 Comparison between Hydraulic and Pneumatic Systems

Usually hydraulic and pneumatic systems and equipment do not compete. They are so dissimilar that there are few problems in selecting any of them that cannot be readily resolved. Certainly, availability is one of the important factors of selection but this may be outweighed by other factors. In numerous instances, for example, air is preferred to meet certain unalterable conditions, that is, in “hot spots” where there is an open furnace or other potential ignition hazard or in operations where motion is required at extremely high speeds. It is often found more efficient to use a combined circuit in which oil is used in one part and air in another on the same machine or process. Table 1.2 shows a brief comparison of hydraulic and pneumatic systems.

Table 1.2 Comparison between a hydraulic and a pneumatic system

S. No.	Hydraulic System	Pneumatic System
1.	It employs a pressurized liquid as a fluid	It employs a compressed gas, usually air, as a fluid
2.	An oil hydraulic system operates at pressures up to 700 bar	A pneumatic system usually operates at 5–10 bar
3.	Generally designed as closed system	Usually designed as open system
4.	The system slows down when leakage occurs	Leakage does not affect the system much
5.	Valve operations are difficult	Valve operations are easy
6.	Heavier in weight	Lighter in weight
7.	Pumps are used to provide pressurized liquids	Compressors are used to provide compressed gases
8.	The system is unsafe to fire hazards	The system is free from fire hazards
9.	Automatic lubrication is provided	Special arrangements for lubrication are needed

1.10 Comparison of Different Power Systems

There are three basic methods of transmitting power: electrical, mechanical and fluid power. Most applications actually use a combination of the three methods to obtain the most efficient overall system. To properly determine which method to use, it is important to know the salient features of each type. For example, fluid systems can transmit power more economically over greater distances than mechanical types. However, fluid systems are restricted to shorter distances compared to electrical systems. Table 1.3 lists the salient features of each type.

Table 1.3 Comparison of different power systems

Property	Mechanical	Electrical	Pneumatic	Hydraulic
Input energy source	I C engines Electric motor	I C engines Water/gas turbines	I C engines Pressure tank	I C engines Electric motor Air turbine
Energy transfer element	Levers, gears, shafts	Electrical cables and magnetic field	Pipes and hoses	Pipes and hoses
Energy carrier	Rigid and elastic objects	Flow of electrons	Air	Hydraulic liquids
Power-to-weight ratio	Poor	Fair	Best	Best
Torque/inertia	Poor	Fair	Good	Best
Stiffness	Good	Poor	Fair	Best
Response speed	Fair	Best	Fair	Good
Dirt sensitivity	Best	Best	Fair	Fair
Relative cost	Best	Best	Good	Fair
Control	Fair	Best	Good	Good
Motion type	Mainly rotary	Mainly rotary	Linear or rotary	Linear or rotary

1.11 Future of Fluid Power Industry in India

The automation market in India is estimated to be 1/10th that of China. If India has to become one of the leading economies in the world, based on manufacturing, it will have to attain higher technological standards and higher level of automation in manufacturing.

In the past 30 years, fluid power technology rose as an important industry. With increasing emphasis on automation, quality control, safety and more efficient and green energy systems, fluid power technology should continue to expand in India.

Fluid power industry is gaining a lot of importance in Indian industry. According to a recent survey, it has shown a growth of 20% over the last 10 years and the size of market is estimated to be close to 5000 crores per annum. This makes it a sizable industry segment in India. The growth rate of this industry in India is typically about twice the growth of economy.

The reasons for this are three-fold:

1. As the economy grows, this industry grows.
2. There is a lot of automation and conversion into more sophisticated manufacturing methods which increases the rate.
3. One of the interesting things happening in this industry is that India is becoming an attractive destination for manufacturing and outsourcing of some of the products.

So these three aspects together create a situation where the growth of this industry is twice the growth of GDP in India.

The fluid power sector in India consists of many sophisticated Indian industries and partnership with number of global fluid power technology leaders that include Festo, Rexroth, Vickers, Eaton, Parker Hannifin, Norgren, Saucer Donfos, Yuken, Siemens, Shamban, Pall and Gates, Rotex, Janatics, Maxwell, Wipro Dynamic Technologies and many more.

One of the major segments for hydraulic industry in India is mobile hydraulics. Because of massive programs on road construction, there is a major expansion of construction machinery industry as well. In addition to this, a trend toward the usage of more sophisticated hydraulics in tractors and farm equipment is witnessed. The manufacturing industry in India is working toward higher automation and quality of output. As Indian industry moves toward

modernization to meet the productivity and to compete in the global market, an excellent potential for the pneumatic industry is expected in India.

Another area of interest for fluid power industry would be the opportunities in defense equipment. Defense is a major market segment in Indian fluid power industry and contributes to over 40% of the market demand. There is also a move toward products with miniature pneumatics, process valves, servo drives, hydraulic power steering with new controls and sophisticated PLC, microprocessor controls.

However, the key input required for the effective utilization of fluid power is education and training of users. So there is a big need for education and training in design application and maintenance of fluid power systems. Rexroth recently opened many competence centers in India to train the manpower and to create awareness about the use of fluid power in Indian industry.

Objective Type Questions

Fill in the Blanks

1. Fluid power is the technology that deals with the generation, _____ and transmission of forces and movement of mechanical elements or systems.
2. The main objective of fluid transport systems is to deliver a fluid from one location to another, whereas fluid power systems are designed to perform _____.
3. There are three basic methods of transmitting power: Electrical, mechanical and _____.
4. Only _____ are capable of providing constant force or torque regardless of speed changes.
5. The weight-to-power ratio of a hydraulic system is comparatively _____ than that of an electromechanical system.

State True or False

1. Hydraulic lines can burst and pose serious problems.
2. Power losses and leakages are less in pneumatic systems.
3. Pneumatic system is not free from fire hazards.
4. Hydraulic power is especially useful when performing heavy work.
5. Water is a good functional hydraulic fluid.

Review Questions

1. Define the term fluid power.
2. Differentiate between fluid transport and fluid power systems.
3. Differentiate between hydraulics and pneumatics.
4. List the six basic components used in a hydraulic system.
5. List the six basic components used in a pneumatic system.
6. List 10 applications of fluid power in the automotive industry.
7. Name 10 hydraulic applications and 10 pneumatic applications.
8. List five advantages and five disadvantages of hydraulics.
9. List five advantages and five disadvantages of pneumatics.
10. List the main components of a fluid power system and their functions.
11. Discuss in detail the future of fluid power industry in India.
12. Compare different power systems used in industries.
13. What is the main difference between an open-loop and a closed-loop fluid power system?
14. List five major manufactures of fluid power equipment and systems in India.
15. List five major manufactures of fluid power equipment and systems in the world.
16. Visit any industry nearby and list the hydraulic/pneumatic parts or systems used and their purposes.
17. Why is the hydraulic power especially useful when performing heavy work?
18. Differentiate between oil hydraulics and pneumatics.
19. List any five applications of fluid power systems.
20. List the main components of a fluid power system and their functions.

Answers

Fill in the Blanks

1. Control
2. Work
3. Fluid power
4. Fluid power systems
5. Less

State True or False

1. True
2. True
3. False
4. True
5. False