Flow rate

Flow rate is the volume of air flowing per unit time.

Units of Flow Rate: Flow rate is measured in lpm (Litre/ Minute) or M^3/ Hour.

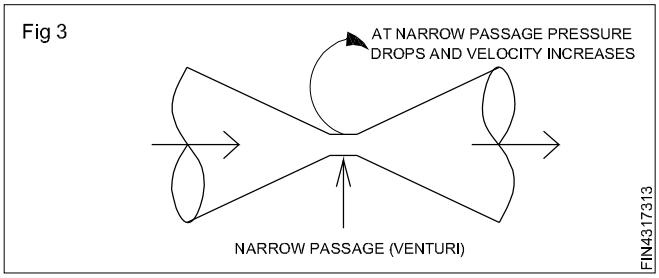
Example: Flow Rate = 10 Litre/ Minute

Or Flow Rate = 50 M^3/ Hour

Properties of Air

- Atmospheirc air posses certain properties as follows:
- Air is a mixture of gasses. (Nitrogen - 78%,Oxygen-21%,Other gases,Water vapour- 1% by Volume)
- It contains dust particles and water vapour.
- Air is compressible means it's volume can be reduced.
- Air does not burn itself.

Fig 3



- Volume of air increases with increase in temperature.
- Moisture or water vapour carrying capacity increases with increase in temperature of air or volume of air.
- Pressure of air increases with reduction of volume.
- Air temperature increases with increase in pressure.
- When air passes through narrow passage pressure drops velocity inceases. (Refer Fig 3)

Applications: Pneumatic is widely used in many industrial automation applications where fast movements of lesser loads are required.

Pneumatics is used to move load with less efforts,general applications are:

- Push - Pull
- Lift - Drop
- Clamp - Unclamp
- Tilt

Boyle's Law

Robert Boyle (1627-1691), an English scientist,was among the first to experiment with the pressure volume relatioship of gas at constant temperature.

Statement: If a given mass of a gas is compressed or expanded at a constant temperature,then the absolute pressure is inversely proportional to the volume.

Pressure $\alpha \frac{1}{\text{Volume'}}$ when temperaute = constant

or pV = constant,$p_1 v_1 = p_2 V_2$

Advantages of Pneumatics

Pneumatics is popular in industrial applications as Low Cost Automation because of following advantages:

- Air is available at free of cost.
- Air is available in unlimited quantity every where.
- Air can compresed,pressurised and can be transported through pipes.
- Air can be exhausted to the environment without any harmful effects.
- Action is fast.
- Speed control is possible.
- System is overload safe.
- Air does not ignite.
- Simple in design and construction.
- Long life and low maintanance
- Components are simple in design and hence cheaper.

Limitations

- Pneumatic system has certain limitations as follows:
- Pneumatic system is economical up to a limit of 3000 kgf force.
- Pneumatics needed fine quality equipment to remove dust and moisture.(Air filters & demoisture)
- Air exhaust is noisy
- Uniform speed is not possible.
- Special lubrication technique is required to avoid friction between internal components.
- In case of leakage pneumatic system becomes costly.
- Compressing air beyound 7 bar is costiler.

Introduction of Hydraulic system

Objectives: At the end of this lesson you shall be able to
- **define hydrauic system**
- **define Pascal's law**
- **state the Bernoulli's principle**

Any working or control system that uses liquid as the transmitting fluid is known as hydraulic system.

The word hydraulic is derived from Greek words "hydra" meaning water and "aulic" meaning pipe.

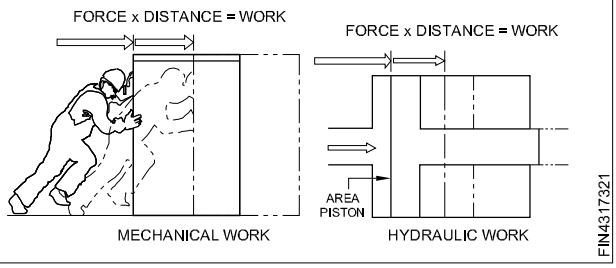
Some common examples of hydraulic system include automobile braking, power steering, elevators, earth moving equipments, jacks, presses, riveting machines, tool feeding mechanisms etc. The liquid used in hydraulics is generally viscous petroleum oils.

The following paragraphs gives basic physical properties and laws that govern liquids, relevant to hydraulic systems.

"Work" is defined as the product of force and the distance in which the object has moved in the direction of force.

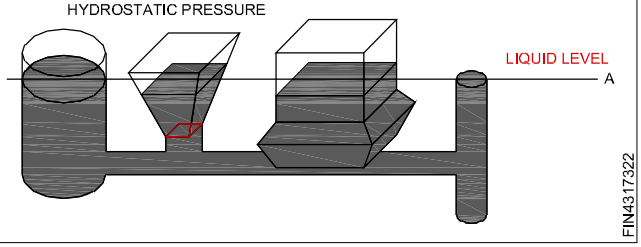
Fig 1 shows the comparison between the work done in a mechanical and hydraulic system.

Fig 1
COMPARISON BETWEEN HYDRAULIC AND MECHANICAL WORK



The Fig 2 shows that different shaped and sized containers inter-connected by a pipe, the level of the liquid remains same. This is because of the internal pressure of the liquid. At any point the liquid attains certain pressure proportional to the height of the liquid above.

Fig 2
HYDROSTATIC PRESSURE



Therefore the higher pressure in any of the container will force the liquid to flow to the next container until the pressure on both the sides are equalised.

Through the line 'A' the pressure in all the open containers remain the same, since height of liquid columns are same.

Pascal's Law

It states that the pressure exerted on a liquid is transmitted equally in all the directions. Fig 3 clearly explains this law followed by Fig 4.

Fig 3

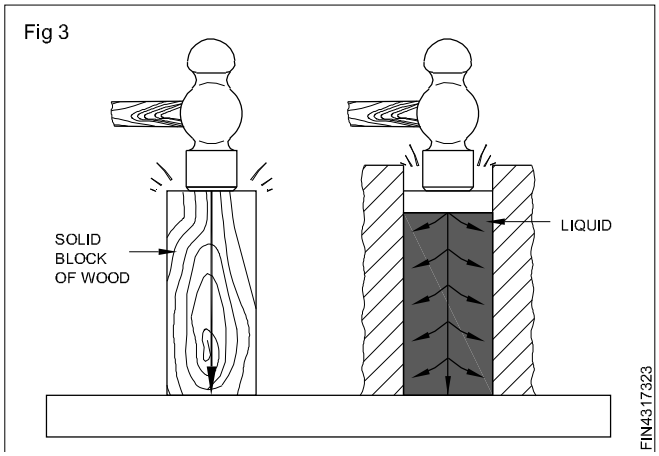
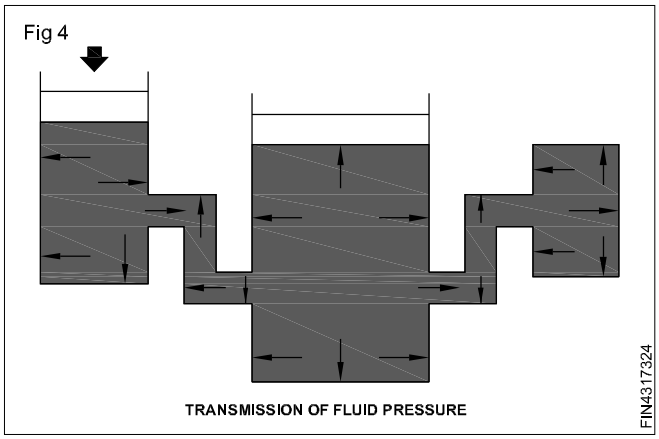
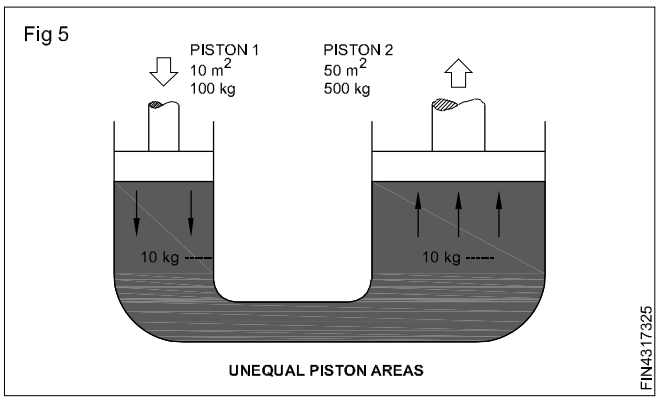


Fig 4



Thus if small amount of pressure is exerted on a smaller piston as shown in Fig 5, the higher force can be attained at the larger piston, since the pressure is equally applied on larger area.

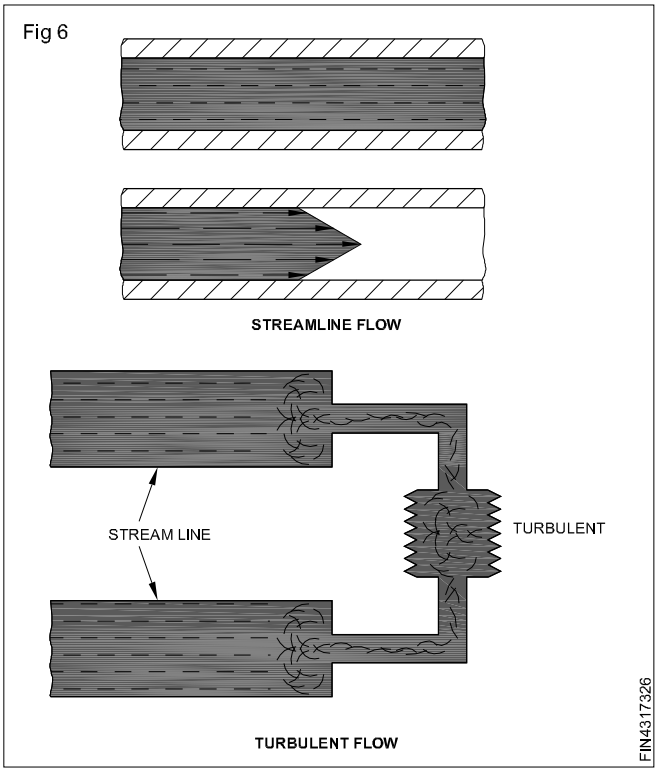
Fig 5



Cavitation

The inter-locked air bubbles and pockets in the hydraulic pipe lines and components is called cavitation. In cavitation the static pressure falls below vapour pressure. The vapour formation condenses resulting in pressure jerks and noise, and heating-up the oil resulting in a turbulent flow. Therefore resulting flow of oil should be a stream line or laminar in the pipe lines (Fig. 6).

Fig 6

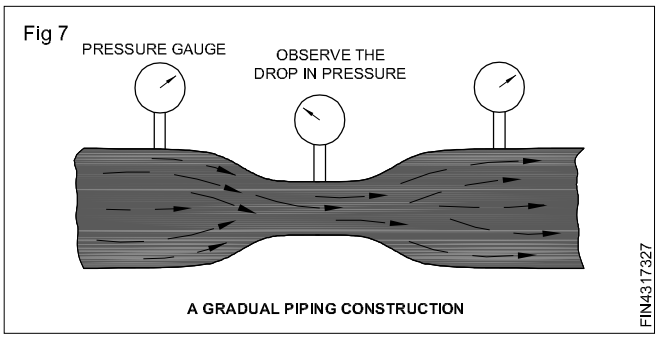


Bernoulli's principle

Kinetic energy is the energy present in oil by virtue of its motion. Potential energy is due to the pressure. The total energy is the sum of these two energies.

The bernoulli's principle states that the total energy of fluid always remains constant. During the course of flow of liquid, the flow increases and pressure decreases when a restriction is encountered. If the flow decreases, liquid pressure increases. Fig 7 Depicts this principle clearly.

Fig 7



Effect of heat

Since the liquids (oil) full in containers cannot expand or be compressed on heat, it exerts pressure on the container thus developing unwanted stresses.

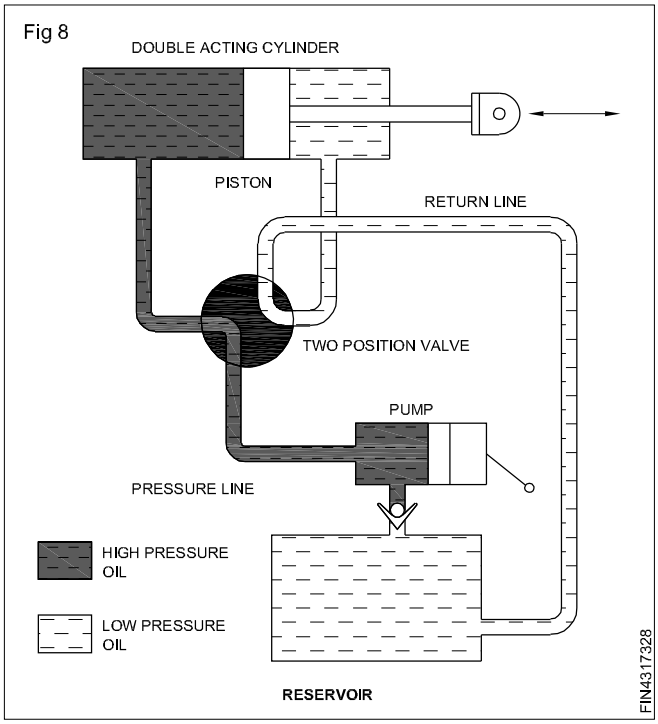
Heat also thins out the oil. The low viscous oil may leak through seals and packings. Heat also causes the deterioration of oil. Hence a suitable cooling system must be provided.

The basic hydraulic system consists of the following elements:

- A reservoir to store the hydraulic fluid
- A pump to provide fluid pressure to the system
- A control valve to direct the flow of fluid
- An actuating unit, such as a cylinder
- A suitable hydraulic fluid
- Piping or tubing to circulate the fluid through the system.

But the following components make up actual hydraulic power system (Fig 8) for a safe and greater range of work.

Fig 8



- A reservoir to store the hydraulic fluid
- A pump to provide fluid pressure to the system
- A filter to remove dust, chips and other foreign particles from the fluid
- A pressure-regulating valve, which keeps the fluid pressure in the main part of the system at the proper level
- An accumulator, which acts as a cushion and prevents large variations in fluid pressure that occurring in the system
- Check valves, which permit fluid flow only in the desired directions.
- A hand pump for operating the system manually if necessary

- A pressure gauge, which indicates the amount of fluid pressure in the system
- A relief valve, which prevents the system pressure from rising too high, if the pressure-regulating valve fails

Comparison between Pneumatics and Hydraulics

Pneumatics	Hydraulics
Confined pressurized system that use moving/air or other gases	Confinded pressurized systems that use moving Liquids
Because gases can be compressed, there is a delay in the movement, the force	Liquids are not very compressible, there is no delay in the movement
Need for air compressor	Hydraulic Fluid-liquid inside system.
Examples:	Cylinder-container holding liquid
Precision drills used by dentists	piston-plunger moving inside cylinder
Pneumatic brakes (air brakes) used by buses, trucks, trains	Pumps-moves liquid in specific direction (usually against gravity)
tampers used to pack down dirt and gravel	Valves-controls the flow of direction (allows flow in one direction)
lungs	Examples:
nail gun	Dump truck lift
dentist chair	Hydraulic lift to lift cars
most industrial pneumatic application uses pressure of 550 to 690 kpa	Jaws of lift
	blood in body Used in cars
	Hydraulic application commonly use from 6.9 to 34.5 mpa.Special high pressure applicaton may exceed 69 mpa.

Advantages of Hydraulics

- Liquids are incompressible and capable of moving much higher loads providing much higher force.
- No need to bleed off " pressurized air to release pressure on the load.
- Highly responsive compared to pneumatics
- Supply more power than pneumatics
- Also provides Lubrication & cooling.