HYDRAULICS AND PNEUMATICS

Pneumatics provides fluid power by means of pressurised air or gases. Hydraulics provides fluid power by means of pressurised liquids, such as oil or water.

Mass density: - Density is the measurement of how tightly a material is packed together. It is defined as the mass per unit volume. Density Formula: $\rho = m/V$, where ρ is the density, m is the mass of the object and V is the volume of the object.

Weight density:- It is defined as the weight per unit volume.

Specific volume:- it I defined as volume per unit mass.

Specific gravity:- Specific Gravity or relative gravity is a dimensionless quantity that is defined as the ratio of the density of a substance to the density of the water.

Viscosity:- resistance of a fluid (liquid or gas) to a change in shape, or movement of neighbouring portions relative to one another. Viscosity denotes opposition to flow. The reciprocal of the viscosity is called the fluidity, a measure of the ease of flow.

Kinematic viscosity:- it is ratio of the dynamic viscosity to the density of the fluid.

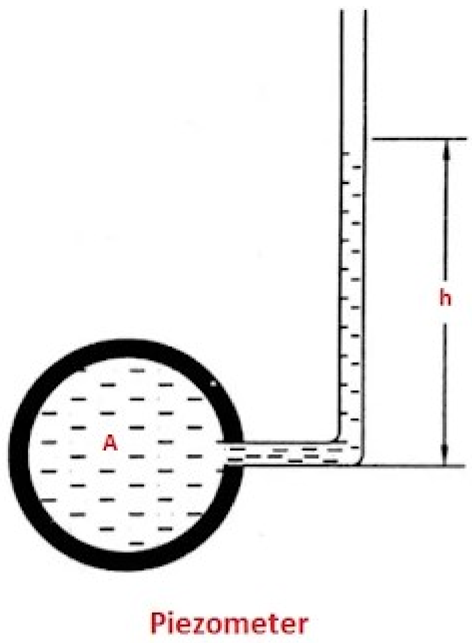
Surface tension:- Surface tension is the tension of the surface film of a liquid caused by the attraction of the particles in the surface layer by the bulk of the liquid, which tends to minimise surface area.

Capillarity:- Capillary action is the movement of a liquid through or along another material against an opposing force, such as gravity. Capillary action depends on cohesion, the attraction between particles of the same substance, and adhesion, the attraction between particles of different substances.

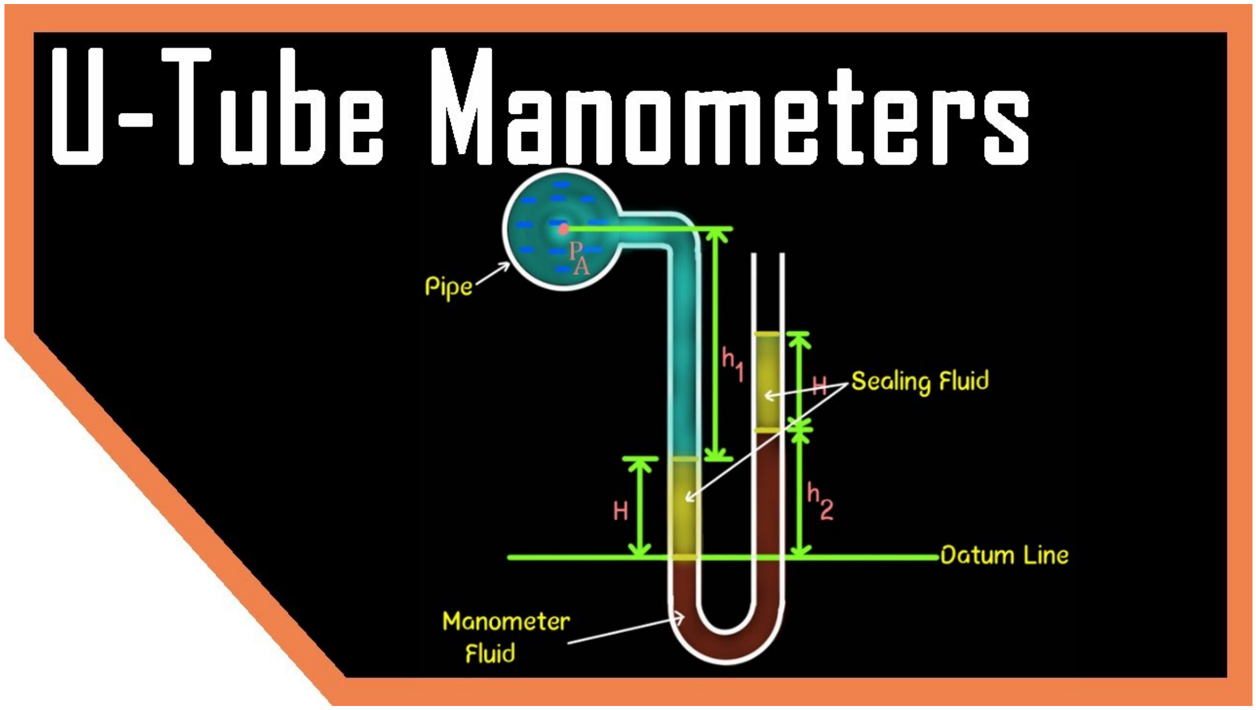
Pressure: Pressure is defined as the physical force exerted on an object. The force applied is perpendicular to the surface of objects per unit area. The basic formula for pressure is F/A (Force per unit area). Unit of pressure is Pascals (Pa). Types of Pressures are Absolute, Atmospheric, Differential, and Gauge Pressure.

Manometer: A Manometer is a device to measure pressures. A common simple manometer consists of a U shaped tube of glass filled with some liquid. Typically the liquid is mercury because of its high density.

Piezometer: -



U tube manometer:



Atmospheric pressure:-

force per unit area exerted by an atmospheric column (that is, the entire body of air above the specified area).

Atmospheric pressure can be measured with a mercury barometer (hence the commonly used synonym *barometric pressure*), which indicates the height of a column of mercury that exactly balances the weight of the column of atmosphere over the barometer. Atmospheric pressure is also measured using an aneroid barometer, in which the sensing element is one or more hollow, partially evacuated, corrugated metal disks supported against collapse by an inside or outside spring; the change in the shape of the disk with changing pressure can be recorded using a pen arm and a clock-driven revolving drum.

Gauge pressure: Gauge pressure, also called overpressure, is the pressure of a system above atmospheric pressure. Gauge pressure is zero-referenced against ambient air (or atmospheric) pressure, so gauge pressure readings include the pressure from the weight of the atmosphere. What this means is that gauge pressure varies according to height above sea level as well as to weather conditions. Given that all of the processes in a refinery or manufacturing plant are at the same air pressure, gauge pressure measurement is sufficient for most industrial applications.

Absolute pressure: - Absolute pressure is the sum of gauge pressure and atmospheric pressure. For reasons we will explore later, in most cases the absolute pressure in fluids cannot be negative. Fluids push rather than pull, so the smallest absolute pressure is zero. (A negative absolute pressure is a pull.)

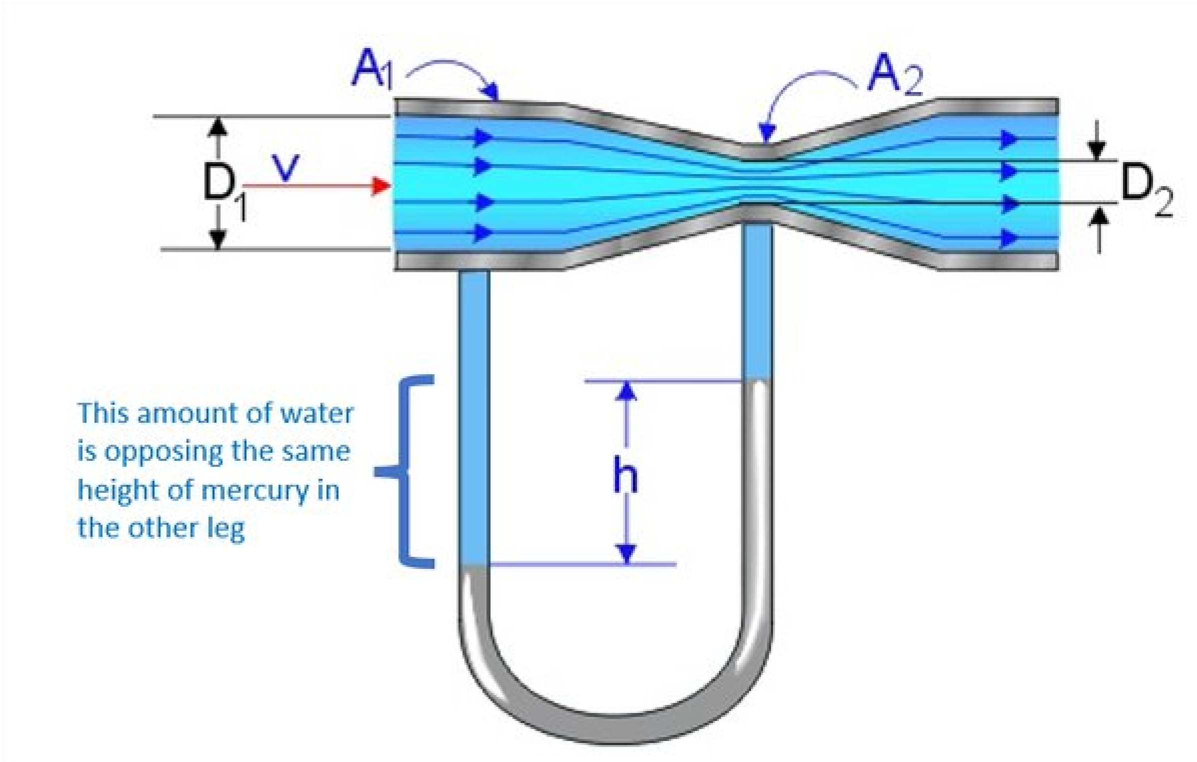
Vacuum: A vacuum is any pressure less than the local atmospheric pressure. It is defined as the difference between the local atmospheric pressure and the point of measurement. A vacuum is correctly measured with a differential pressure transducer that has one port open to atmosphere

Bernoulli's theorem:-

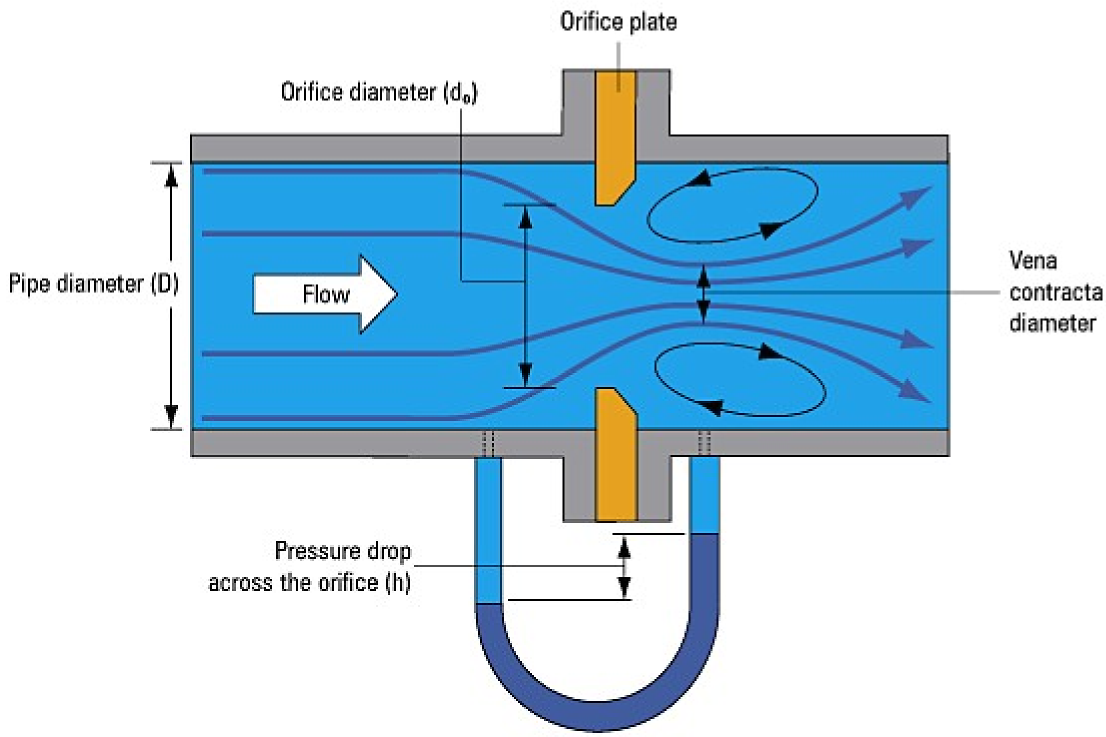
Bernoulli's theorem, also known as Bernoulli's principle, states that the whole mechanical energy of the moving fluid, which includes gravitational potential energy of elevation, fluid pressure energy, and kinetic energy of fluid motion, remains constant. This equation is known as Bernoulli's equation.

Continuity equation: The continuity equation (Eq. 4.1) is the statement of conservation of mass in the pipeline: mass in minus mass out equals change of mass. The first term in the equation, $\partial (\rho v A) / \partial x$, is “mass flow in minus mass flow out” of a slice of the pipeline cross-section.

Venturimeter:- A venturi meter is a measuring or also considered as a meter device that is usually used to measure the flow of a fluid in the pipe. A Venturi meter may also be used to increase the velocity of any type fluid in a pipe at any particular point. It basically works on the principle of Bernoulli's Theorem.



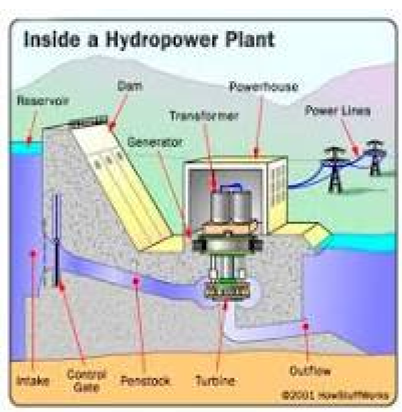
Orifice meter:- An orifice meter is a piece of equipment used to measure the flow rate of a gas or a fluid. It mainly consists of an orifice plate, an orifice plate housing, and a meter tube.



Pitot tube:-

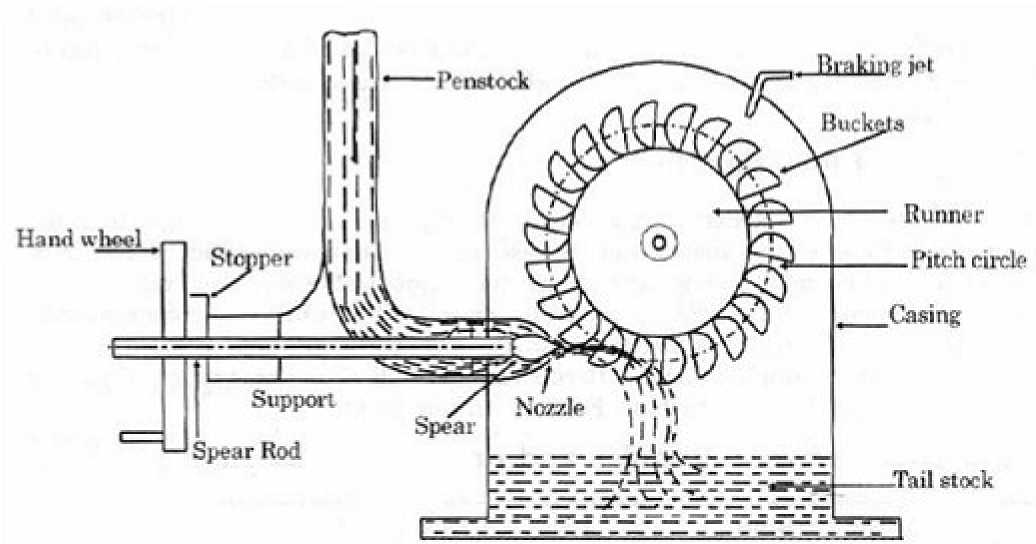
Pitot tubes were invented by Henri Pitot in 1732 to measure the flowing velocity of fluids. Basically a differential pressure (d/p) flow meter, a pitot tube measures two pressures: the static and the total impact pressure.

Hydro electric power plant:

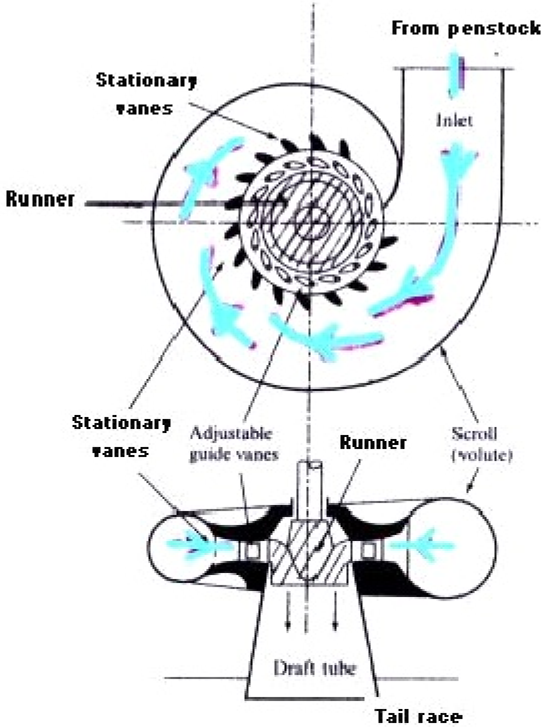


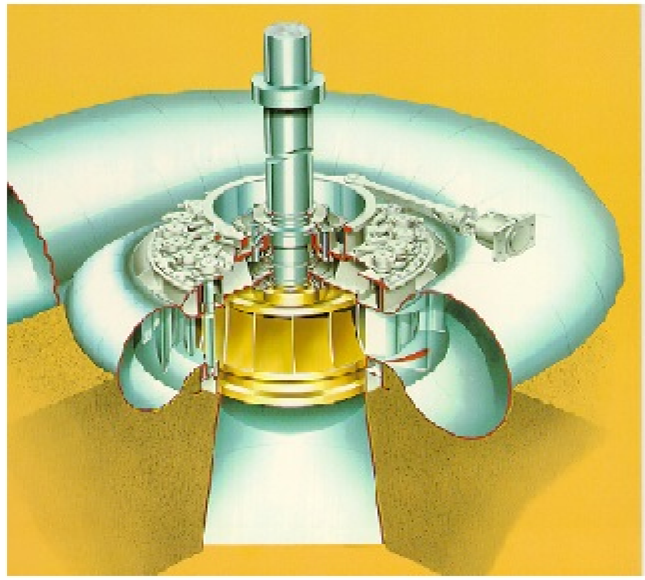
Water turbine: - Water turbine is used to convert energy contained in water, potential energy or kinetic energy, into mechanical or electrical energy. There are two types of water turbine, the reaction water turbine and the impulse water turbine.

Pelton turbine: - The **Pelton wheel** or **Pelton Turbine** is an impulse-type water turbine invented by American inventor Lester Allan Pelton in the 1870s.[1][2] The Pelton wheel extracts energy from the impulse of moving water, as opposed to water's dead weight like the traditional overshot water wheel. Many earlier variations of impulse turbines existed, but they were less efficient than Pelton's design. Water leaving those wheels typically still had high speed, carrying away much of the dynamic energy brought to the wheels. Pelton's paddle geometry was designed so that when the rim ran at half the speed of the water jet, the water left the wheel with very little speed; thus his design extracted almost all of the water's impulse energy—which made for a very efficient turbine.

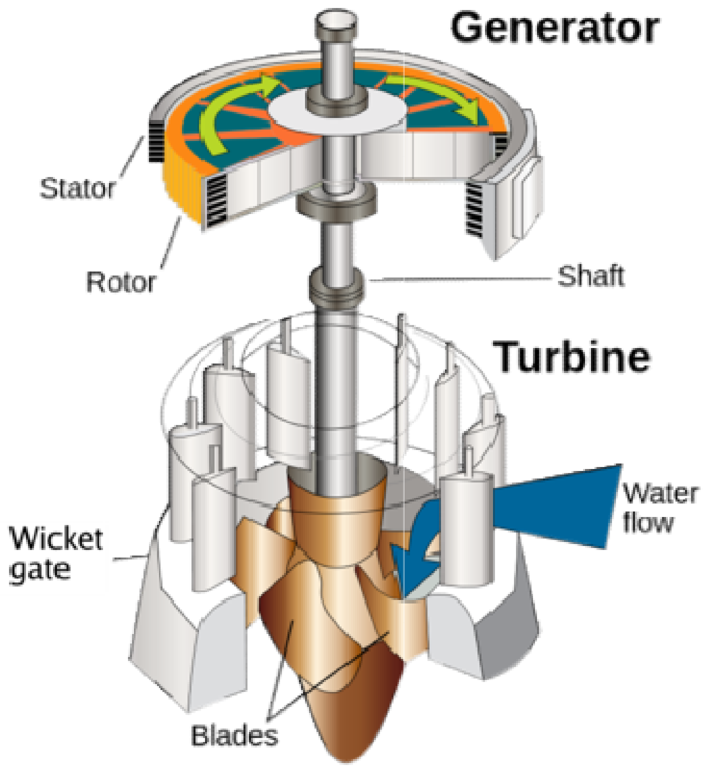


Francis turbine:- The Francis turbine is a reaction turbine, which means that the working fluid changes pressure as it moves through the turbine, giving up its energy. The turbine is located between the high-pressure water source and the low-pressure water exit, usually at the base of a dam.





Kaplan turbine:- A Kaplan turbine is basically a propeller with adjustable blades inside a tube. It is an axial-flow turbine, which means that the flow direction does not change as it crosses the rotor.



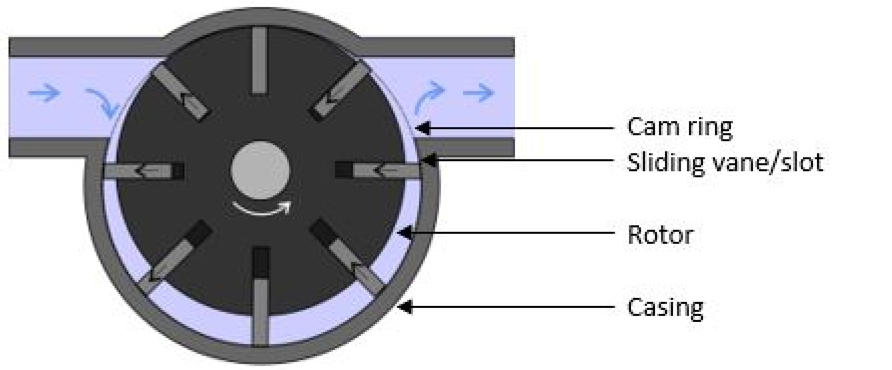
Vane Pump:-

Vane pumps are a type of rotary positive displacement pump. A set of paddle-like vanes, mounted radially on a cylindrical rotor, create a number of compartments in which fluid can be trapped and transported through the system. The vanes maintain a close seal against the wall of the pumping chamber preventing fluid from leaking back across the pump. Vane pumps are particularly useful for pumping thin liquids at high pressures. The pumps give low pulsation, accurate flows and have hardened components to resist wear and extend pump life.

Working:

During a rotation cycle, the volume between adjacent vanes changes because of the rotor's eccentric mounting position. This creates the pumping action. There are two main types of vane pumps: sliding vane and flexible vane (see Figure 1):

Sliding Vane Pump



Flexible Vane Pump

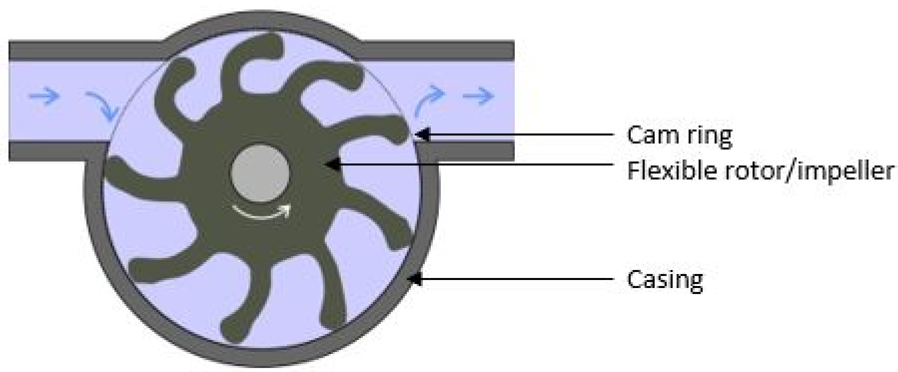


Figure 1. Vane pumps: sliding vane (top) and flexible vane (bottom)

Gear pump:- A **gear pump** uses the meshing of gears to pump fluid by displacement.[1] They are one of the most common types of pumps for hydraulic fluid power applications. The gear pump was invented around 1600 by Johannes Kepler.[2]

Gear pumps are also widely used in chemical installations to pump high-viscosity fluids. There are two main variations: *external gear pumps* which use two external spur gears, and *internal gear pumps* which use an external and an internal spur gear (internal spur gear teeth face inwards, see below). Gear pumps provide *positive displacement* (or *fixed displacement*), meaning they pump a constant amount of fluid for each revolution. Some gear pumps are designed to function as either a motor or a pump.

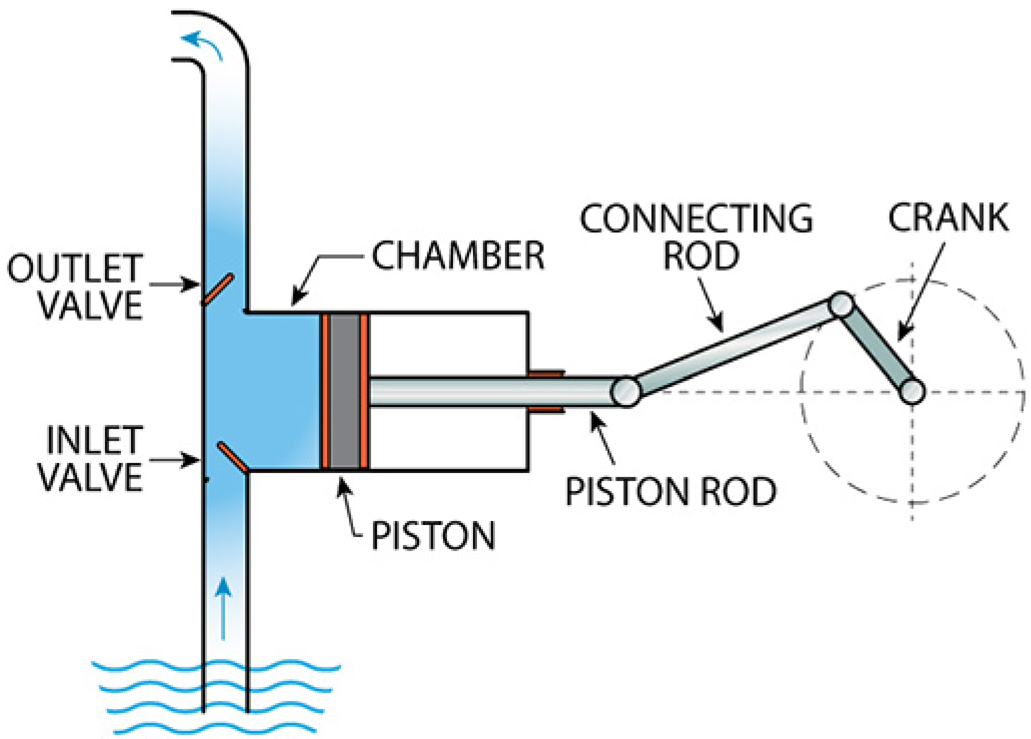

As the gears rotate they separate on the intake

side of the pump, creating a void and suction which is filled by fluid. The fluid is carried by the gears to the discharge side of the pump, where the meshing of the gears displaces the fluid. The mechanical clearances are small— on the order of 10 µm. The tight clearances, along with the speed of rotation, effectively prevent the fluid from leaking backwards.

The rigid design of the gears and houses allow for very high pressures and the ability to pump highly viscous fluids.

Reciprocating pump:-

A reciprocating pump is a positive displacement pump that captures a moving fluid in a cavity and then discharges a fixed amount of it via mechanical pressure. It is a constant volume pump that operates in low flow and high discharge pressure environments. Milton Roy's reciprocating pumps can handle flow rates from 0.024 gallons per hour (0.09 liters per hour) to 12,681 gallons per hour (48 cubic per hour) and discharge pressures up to 15,000 psi (1,034 bar).



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.

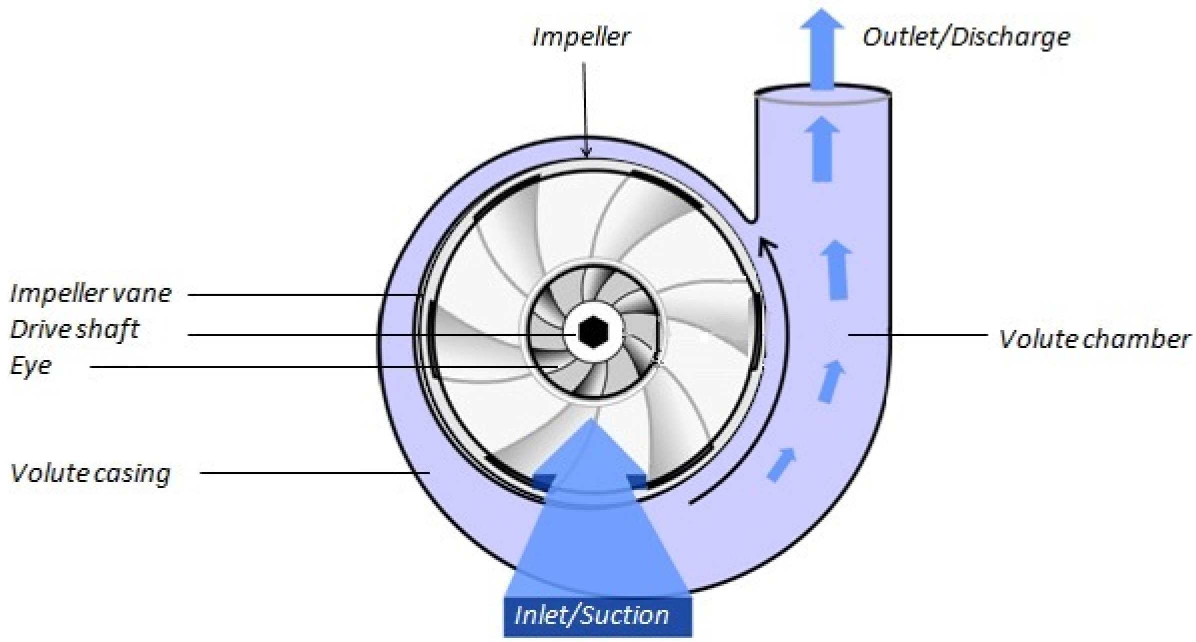


Figure 2. Volute case design