P_v is the vapor pressure of the liquid being pumped at the particular temperature in question.

The available net positive suction head (NPSH) can also be written as:

$$NPSH = h_s - \frac{P_v}{\rho\, g}$$

The available net positive suction head (NPSH) in a system should always be positive i.e. the suction head always be capable of overcoming the vapor pressure (Pv) since the frictional head loss (hF)s increases with increasing pumping rate.

At the boiling temperature of the liquid Ps and Pv are equal and the available NPSH becomes [zs-(hF)s]. In this case no suction lift is possible since zs must be positive. If the term (Ps-Pv) is sufficiently large, liquid can b lifted from below the centerline of the pump. In this case zs is negative.

From energy consideration it is immaterial whether the suction pressure is below atmospheric pressure or well above it, as long as the fluid remains liquid. However, if the suction pressure is only slightly greater than the vapor pressure, some liquid may flash to vapor inside the pump, a process called "*Cavitation*", which greatly reduces the pump capacity and severe erosion.

If the suction pressure is actually less than the vapor pressure, there will be vaporization in the suction line, and no liquid can be drawn into the pump.

To avoid cavitation, the pressure at the pump inlet must exceed the vapor pressure by a certain value, called the " net positive suction head (NPSH)". The required values of NPSH is about 2-3 m H_2o for small pump; but it increases with pump capacity and values up to 15 m H2o are recommended for very large pump.

5.4 Power Requirement

The power requirement to the pump drive from an external source is denoted by (P). It is calculated from Ws by:

$$\boxed{P = \dot{m}Ws = \frac{Q\Delta P}{\eta} = \frac{Q\Delta h\ \rho\ g}{\eta} = \frac{\dot{m}\Delta hg}{\eta}}$$

The mechanical efficiency (η) decreases as the liquid viscosity and hence the frictional losses increase. The mechanical efficiency is also decreased by power losses in gear, Bering, seals, etc.

These losses are not proportional to pump size. Relatively large pumps tend to have the best efficiency whilst small pumps usually have low efficiencies. Furthermore high-speed pumps tend to be more efficient than low-speed pumps. In general, high efficiency pumps have high NPSH requirements.

5.5 Types of Pumps

Pumps can be classified into: -

1- Centrifugal pumps.
2- Positive displacement pumps.

1- Centrifugal pumps

This type depends on giving the liquid a high kinetic energy, which is then converted as efficiently as possible into pressure energy. It used for liquid with very wide ranging properties and suspensions with high solid content including, for example,

cement slurries, and may be constructed from a very wide range of corrosion resistant materials. Process industries commonly use centrifugal pumps. The whole pump casing may be constructed from plastics such as polypropylene or it may be fitted with a corrosion resistant lining. Because it operates at high speed, it may be directly coupled to an electric motor and it will give a high flow rate for its size. They are available in sizes about 0.004 to 380 m3/min [1-100,000 gal/min] and for discharge pressures from a few m H2o head to 5,000 kPa.

In this type of pump (Figure 2), the fluid is fed to the center of a rotating impeller and is thrown outward by centrifugal action. As a result of the high speed of rotation the liquid acquires a high kinetic energy and the pressure difference between the suction and delivery sides arises from the interconversion of kinetic and pressure energy.

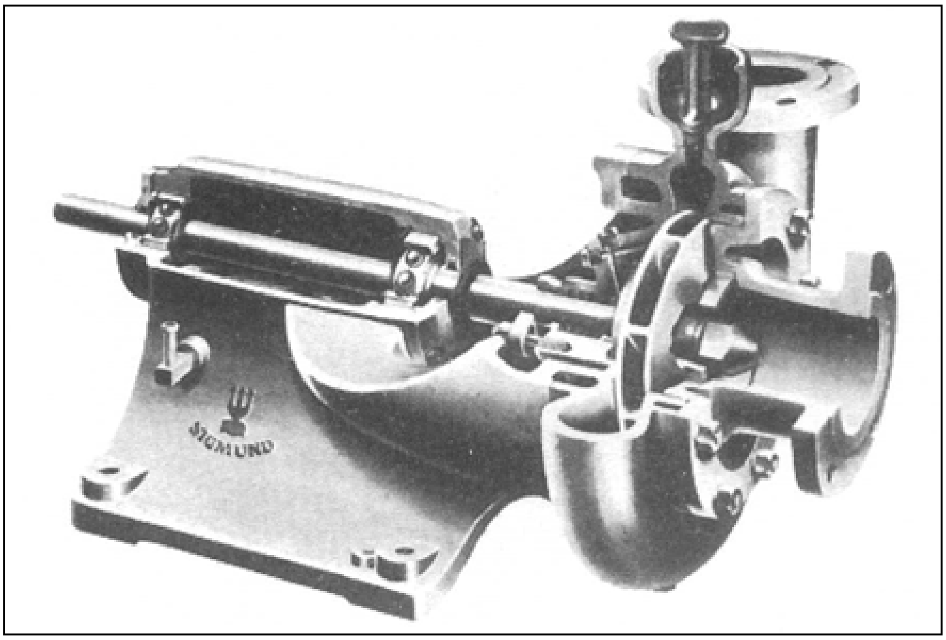

Figure (2) Section of centrifugal pump

The impeller (Figure 3) consists of a series of curved vanes so shaped that the flow within the pump is as smooth as possible. The greater the number of vanes on the impeller, the greater is the control over the direction of motion of the liquid and hence the smaller are the losses due to turbulence and circulation between the vanes. In the open impeller, the vanes are fixed to a central hub, whereas in the closed type the vanes are held between two supporting plates and leakage across the impeller is reduced.

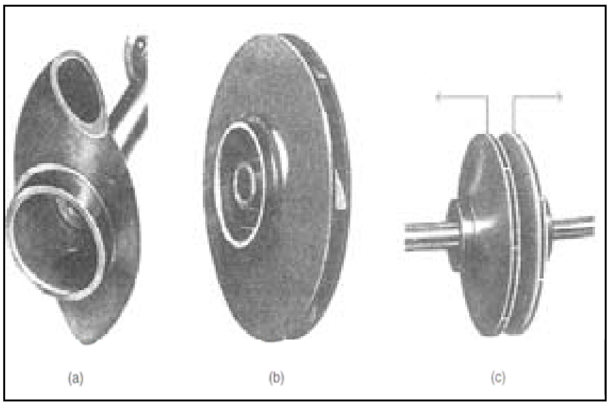

Figure (3) Types of impeller
(a) for pumping suspensions (b) standard closed impeller (c) double impeller

The liquid enters the casing of the pump, normally in an axial direction, and is picked up by the vanes of the impeller. In the simple type of centrifugal pump, the liquid discharges into a volute, a chamber of gradually increasing cross-section with a tangential outlet. A volute type of pump is shown in Figure 4. In the turbine pump