HEAD OF A PUMP

The head of a centrifugal pump may be expressed in the following ways:

Static head;

Manometric head;

Total, gross or effective head

(i) **Static head.** The *sum of suction head and delivery head is known as **static head.*** This is represented by H_{stat} and is written as:

$$H_{stat} = h_s + h_d \quad ...(3.4)$$

where, h_s = Suction head (it is the vertical height of the centre line of the pump shaft above the liquid surface in the sump from which the liquid is being raised), and

h_d = Delivery head (it is vertical height of the liquid surface in the tank / reservoir to which the liquid is delivered above the centre line of the pump shaft).

The terms h_s and h_d are known as *static suction lift* and *static delivery lift* respectively.

(ii) **Manometric head.** *The head against which a centrifugal pump has to work is known* as the ***manometric head.*** It is the head measured across the pump inlet and outlet flanges. It is denoted by H_{mano} and is given by the following expressions:

(*i*) H_{mano} = Head imparted by the impeller to liquid – loss of head in the pump (*i.e.* impeller, and casing)

$$= \frac{V_{w2}u_2}{g} - (h_{Li} + h_{Lc}) \quad ...(3.5)$$

(where, h_{Li} and h_{Lc} are the losses of head in the *impeller* and *casing* respectively.)

$$= \frac{V_{w2}u_2}{g} \quad \text{...if loss of head in the pump is } zero. \quad ...(3.6)$$

Losses And Efficiencies of Centrifugal of Pumps

When a centrifugal pump operates, the various losses which occur are as follows:

1. Hydraulic losses:

(*i*) *Hydraulic losses in the pump:*

(*a*) Shock or eddy losses at the entrance to and exit from the impeller.

(*b*) Losses due to friction in the impeller.

(*c*) Friction and eddy losses in the guide vanes/diffuser and casing.

(*ii*) *Other hydraulic losses:*

(*a*) Friction and other minor losses in the suction pipe.

(*b*) Friction and other minor losses in the delivery pipe.

2. Mechanical losses:

(*i*) Losses due to disc friction between the impeller and the liquid which fills the clearance spaces between the impeller and casing.

(*ii*) Losses pertaining to friction of the main bearing and glands.

3. Leakage loss:

The loss of energy due to leakage of liquid is known *as leakage loss.* The various losses in a centrifugal pump are shown diagramatically in Fig. 3.6.

Efficiencies of a Centrifugal Pump

The various efficiencies of a centrifugal pump are:

(i) Manometric efficiency (ηmano), (ii) Volumetric efficiency (ηv),

(iii) Mechanical efficiency (ηm), and (iv) Overall efficiency (η0).

(*i*) **Manometric efficiency (η_{mano}).** *The ratio of the manometric head developed by the pump to the head imparted by the impeller to the liquid is known as* ***manometric efficiency.*** Thus,

$$\eta_{mano} = \frac{\text{Manometric head}}{\text{Head imparted by impeller to liquid}}$$

or,

$$\eta_{mano} = \frac{H_{mano}}{\left(\frac{V_{w2}u_2}{g}\right)} = \frac{gH_{mano}}{V_{w2}u_2} \quad ...(3.9)$$

(*ii*) **Volumetric efficiency (η_v).** *The ratio of quantity of liquid discharged per second from the pump to quantity passing per second through the impeller is known as* ***volumetric efficiency.*** Thus,

$$\eta_v = \frac{\text{Liquid discharged per second from the pump}}{\text{Quantity of liquid passing per second through the impeller}}$$

or,

$$\eta_v = \frac{Q}{Q+q}$$

where, Q = Actual liquid discharged at the pump outlet per second, and

q = Leakage of liquid per second from the impeller (through the clearances between the impeller and casing).

(*iii*) **Mechanical efficiency (η_m).** *The ratio of the power delivered by the impeller to the liquid to the power input to the pump shaft is known as* ***mechanical efficiency.*** Thus,

$$\eta_m = \frac{\text{Power delivered by the impeller to the liquid}}{\text{Power input to the pump shaft (P)}}$$

or,

$$\eta_m = \frac{w(Q+q)(V_{w2}u_2/g)}{P} \quad ...(3.11)$$

$$= \frac{P - P_{mech\ loss}}{P} \quad ...[3.11(a)]$$

(iv) **Overall efficiency (η_0).** *The ratio of power output of the pump to the power input to the pump is known as overall efficiency.* Thus,

$$\eta_0 = \frac{\text{Power output of the pump}}{\text{Power input to the pump / shaft}} = \frac{wQH_{mano}}{P} \quad ...(3.12)$$

Also,

$$\eta_0 = \eta_{mano} \times \eta_v \times \eta_m$$

$$= \frac{H_{mano}}{(V_{w2}u_2/g)} \times \frac{Q}{(Q+q)} \times \frac{w(Q+q)(V_{w2}u_2/g)}{P}$$

$$= \frac{wQH_{mano}}{P}$$, which is the same as eqn. (3.12)