



The Centrifugal Pump

INTRODUCTION

- ▶ The pump is mechanical device which conveys liquid from one place to another place. It can be defined as a hydraulic machines which converts the mechanical energy into hydraulic energy (pressure energy of liquid)
- ▶ The pump is power absorbing machines.
- ▶ The power can be supplied to the pump by a prime motor like an electric motor, an internal combustion engine or turbine.
- ▶ Pumping means addition of energy to a liquid to move it from one place to the another, and this done by means of piston, plunger, impeller, propeller, gears or screw depending upon types of pumps.

- ▶ The purpose of pumps may be increasing the pressure energy, imparting kinetic energy, lifting and circulating or extracting liquids etc.
- ▶ The pumps are used for various applications in various fields as follows:
 1. Thermal engineering:
 - To feed water in to the boiler
 - To circulate the water in condenser
 - To circulate lubricating oil in the proper place in various machines
 2. Agriculture and irrigation:
 - To lift water from deep well
 - To convey water from one place to another
 3. Chemical industries:
 4. Municipal water works and drainage system
 5. Hydraulic control systems

CLASSIFICATION OF PUMPS

- ▶ The pump can be classified according to principle by which the energy added to the fluid and their design features as follows:
 1. Positive displacement pump: These pumps operate on the principle of a definite quantity of liquid is discharged or displaced due to the positive or real displacement of working element like piston, plunger, gears, etc..
 1. **Reciprocating pump**:
 1. Piston pumps:
 1. Single cylinder single acting or double acting.
 2. Double cylinder single acting or double acting.
 2. Plunger pumps
 3. Bucket pump–Hand pumps
 2. **Rotary pumps**:
 1. Gear pumps
 2. Vane/lobe pumps
 3. Screw pumps

2. Roto-dynamic pump: These pumps operate on the principle of the rise in pressure energy of liquid by dynamic action of liquid. The dynamic action of liquid is carried by revolving wheel which has curved vanes on it. This wheel is known as impeller.

1. **Radial flow pump**: In this pump, addition of energy to the liquid occurs when the flow of liquid in radial path.

1. Centrifugal pumps:

1. Single stage

2. Multi stage

2. **Axial flow pump**: In this pump, addition of energy to the liquid occurs when the flow of liquid in axial direction.

3. **Mixed flow pump**: In this pump, addition of energy to the liquid occurs when the flow of liquid in axial as well as radial directions.

3. Other type of pumps: This type of pumps does not belong to the category of positive displacement or roto-dynamic type pumps as follows:

1. Jet pump

2. Air lift pump

CLASSIFICATION OF CENTRIFUGAL PUMP

1. According to shape of impeller and casing:-

1. Volute or spiral casing type pump:

- Impeller is surrounded by the spiral casing known as volute chamber provides a gradual increasing area to the discharge pipe.
- Simple in construction.
- Greater eddy losses which decreases overall efficiency.

2. Vortex (whirlpool) casing type pump:

- Modified type of volute casing pump.
- Circular chamber is inserted between the impeller and volute chamber this chamber is known as vortex or whirlpool chamber.
- Improvement in performance due to reduces of eddies.

3. Diffuser type (turbine) pump:

- The impeller is surrounded by a series of stationary guide blades mounted on a ring which is known as diffuser.
- More pressure head is developed compared to vortex & volute type pump.
- Higher efficiency.

2. According to type of impeller:–

1. Closed or shrouded impeller:

- The vanes are covered with metal side plate (shrouds) on both sides.
- Wear is reduced.
- Long life performance with full capacity.
- High efficiency.
- This type of pump is used when liquid to be pumped is pure and free from debris.

2. Semi-open impeller:

- In this single plate (shroud) on the back side.
- This pump handles liquids containing fibrous materials like paper pulp, sugar molasses and sewage water etc.

3. Open impeller:

- Impeller vanes are not containing shrouds (side plate) on either side.
- Vanes are open on both sides.
- Handle abrasive liquids like a mixture of water-sand, pebbles and clay etc.

3. According to working head:–

1. Low head centrifugal pump: head up to 15m.

2. Medium head centrifugal pump: head between 15 to 40m.

3. High head centrifugal pump: head above 40m.

4. According to number of stages:-

1. Single stage centrifugal pump:

- Only one impeller.
- Can not produce sufficient high pressure head efficiently.
- Mostly used for lower head and lower discharge.

2. Multi-stage centrifugal pump:

- Two or more identical impellers mounted on same shaft in series or on different shaft in parallel.
- Two types (1). Impeller in series &
(2). Impeller in parallel
- If the pump has more than one impellers and all the impellers are mounted on a single shaft, arranged serially one after other and enclosed in same casing known as multi-stage pump of impeller in series.
- If the pump has more than one impellers and each impeller is mounted on each shaft and keeping shaft parallel to one another is known as multi-stage pump of impeller in parallel.
- Produce a high pressure head (use impeller in series).
- Discharge a large quantity of liquid (use impeller in parallel).

5. According to direction of flow through impeller:–

1. Radial flow pump:

- Liquid enters the impeller axially at the center and flow radially to the periphery.
- The head is developed by the action of centrifugal force upon the liquid.

2. Axial flow pump:

- Liquid enters impeller axially and also discharge axially.
- Head is developed by the propelling or lift action of the vanes in the liquid.
- Discharge large quantity of water at comparatively low heads.
- Suitable for irrigation purposes.

3. Mixed flow pump:

- Flow of liquid through impeller is a combination of axial and radial direction.
- Head is developed partly by the action of centrifugal force and partly by the propelling force.
- Most suitable for irrigation purpose where a large quantity of water is required at lower head.

6. According to number of entrances to the impeller:–

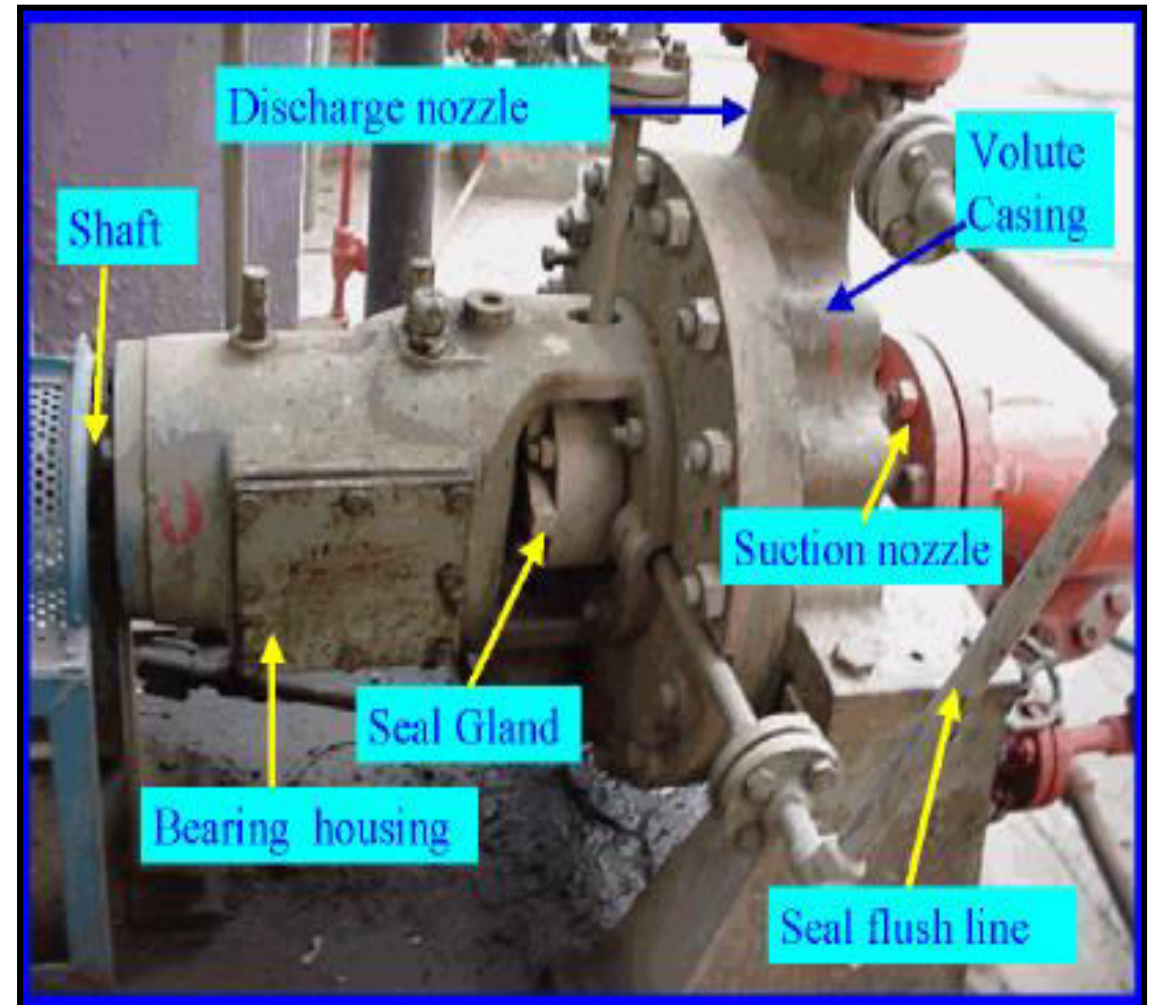
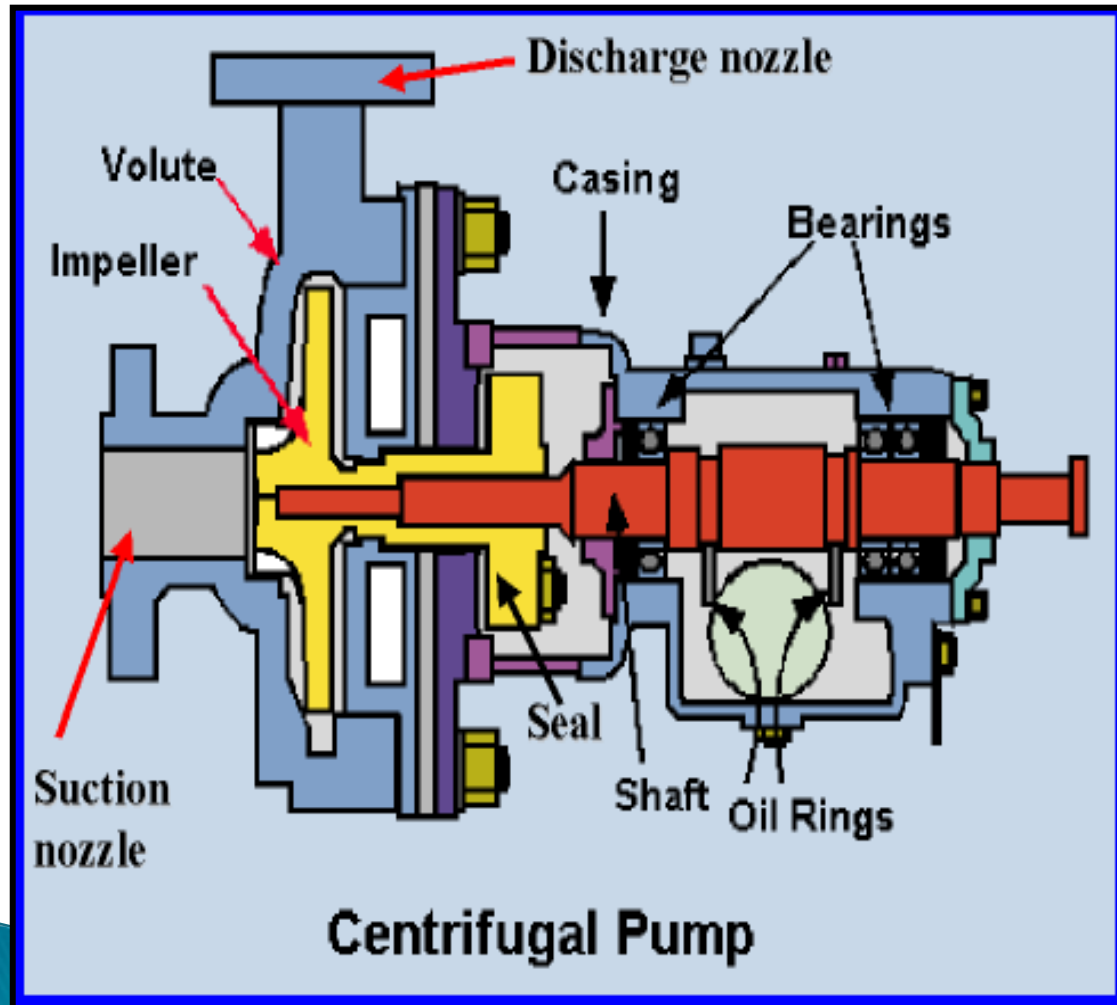
1. Single suction pump: Water is entered from one side of impeller.

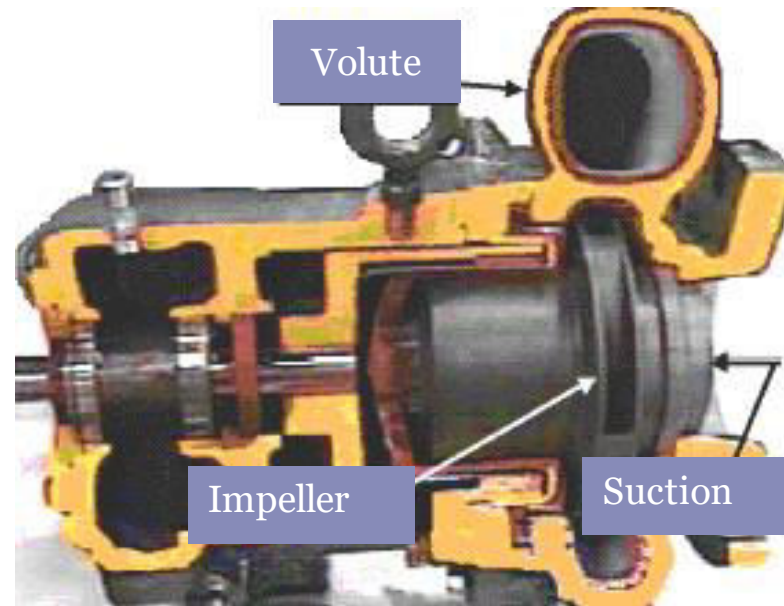
2. Double suction pump: Water is entered from both side of impeller.

7. According to specific speed of pump:-

1. Low specific speed pump:
 - specific speed in range 10–80
 - Example: Radial flow pump
2. Medium specific speed pump:
 - specific speed in range 80–160
 - Example: Mixed flow pump
3. High specific speed pump:
 - specific speed in range 160–500
 - Example: Axial flow pump

MAIN PARTS OF CENTRIFUGAL PUMP:

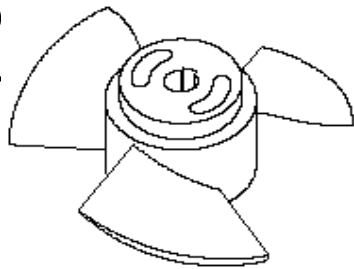




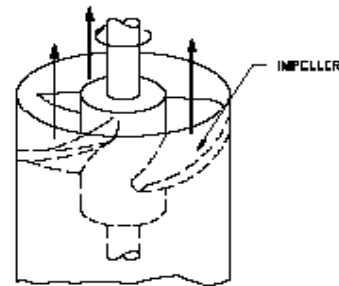
- ▶ **Casing:** It is an air tight passage surrounding the impeller and its designed in such a way that the kinetic energy of liquid coming from impeller is converted into pressure energy before the delivery pipe
 - There are basically three types of casing
 1. Volute (spiral) casing
 2. Vortex (whirlpool) chamber casing
 3. Volute casing with guide blades

- ▶ **Impeller:** It is rotating element of centrifugal pump. It consists of finite number of backward curved vanes. The number of vanes normally 6 to 12 in the impeller. Impeller is mounted on shaft which is coupled with the shaft of electric motor. In impeller the kinetic energy of liquid is increased.

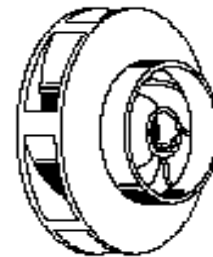
▶ Different figures



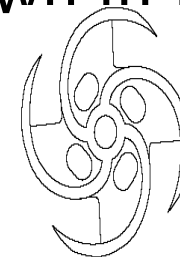
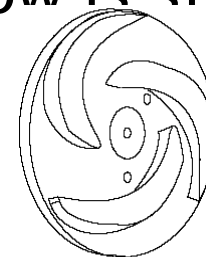
Axial flow



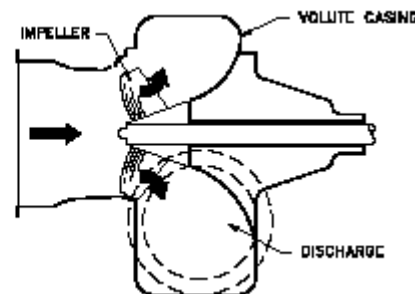
different types of flow is shown in below



Radial flow



Mixed flow



▶ Suction pipe with foot valve and a strainer

- **Suction pipe:** It is pipe whose one end is connected to the inlet of the pump and other end dips in to water in a liquid sump.
 - **Foot valve:** It is a non return is essentially for all types of rotodynamic pumps. It helps in allowing the liquid to enter into pump in upward direction only and does not allow the liquid to move downwards.
 - **Strainer:** The strainer is essential for all type of pumps. It protects pump against foreign material passes through the pump, without strainer pump may be choked.
- ▶ **Delivery Pipe:** A pipe whose one end is connected to the pump and other end delivers at a required height is called delivery pipe.

HEADS OF PUMP

where :

V_s = Velocity of fluid in the suction pipe

V_d = Velocity of fluid in the delivery pipe

h_s = Suction head.

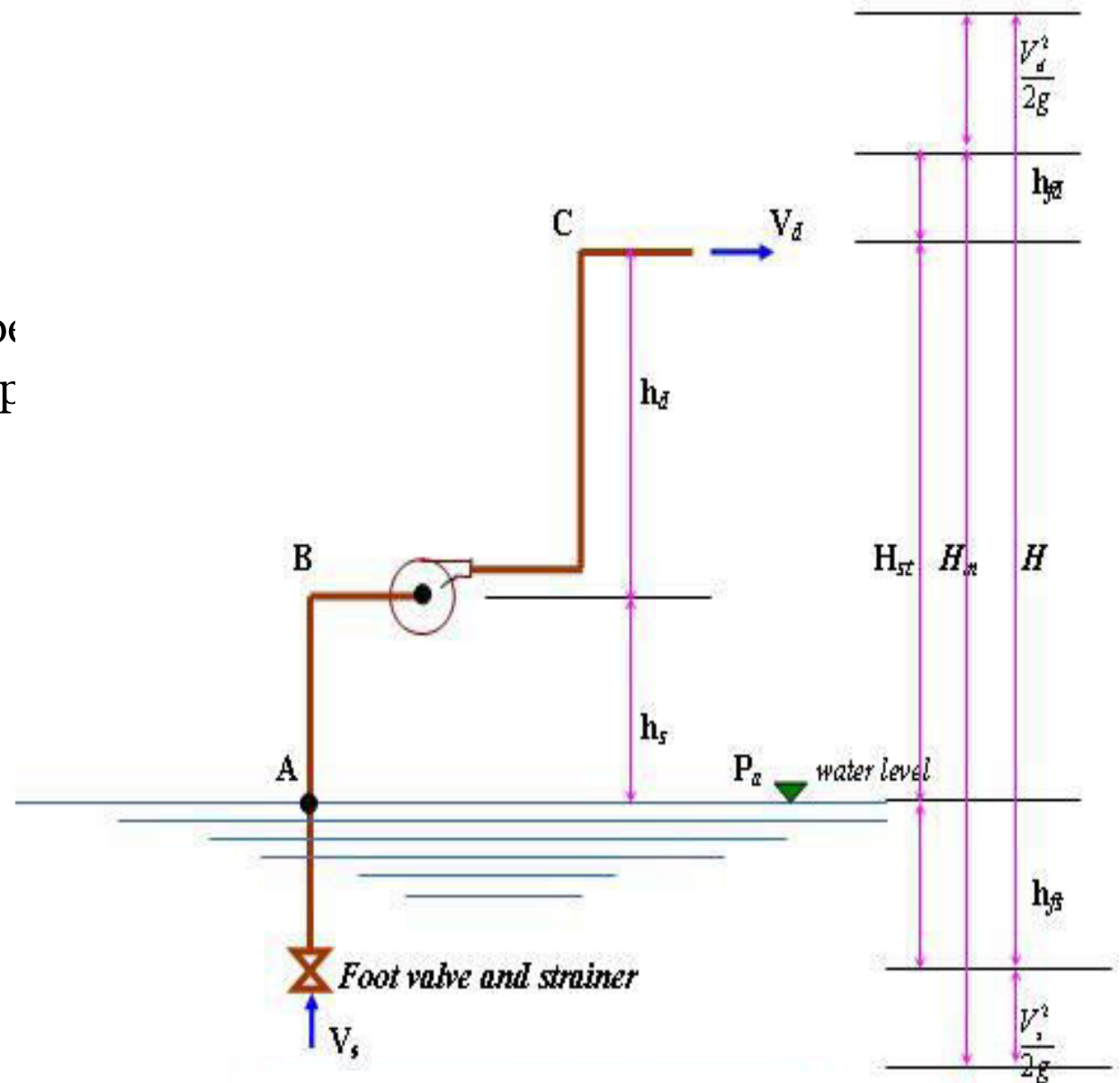
h_d = Delivery head.

h_{fs} = head losses in the suction pipe.

h_{fd} = head losses in the delivery pipe.

Static head (H_{st}):

$$H_{st} = h_s + h_d$$



Manometric head (H_m):

$$H_m = \frac{p_d - p_s}{\gamma} + (z_d - z_s) \quad \text{but} \quad \frac{p_d}{\gamma} = h_d + h_{fd} \quad \text{and} \quad \frac{p_s}{\gamma} = -(h_s + h_{fs})$$

$$H_m = \frac{V_s^2}{2g} + h_s + h_{fs} + h_d + h_{fd}$$

$$= H_{st} + h_f + \frac{V_s^2}{2g}$$

(where $h_{fd} = f \frac{L}{D} (V_d^2 / 2g)$)

where $h_f = h_{fs} + h_{fd}$

$$H_m = h' - H_L = \frac{V_{w2} U_2}{g} - H_L$$

(where H_L = impeller losses)

Total head (H):

$$H = \frac{p_d - p_s}{\gamma} + (z_d - z_s) + \frac{V_d^2 - V_s^2}{2g}$$

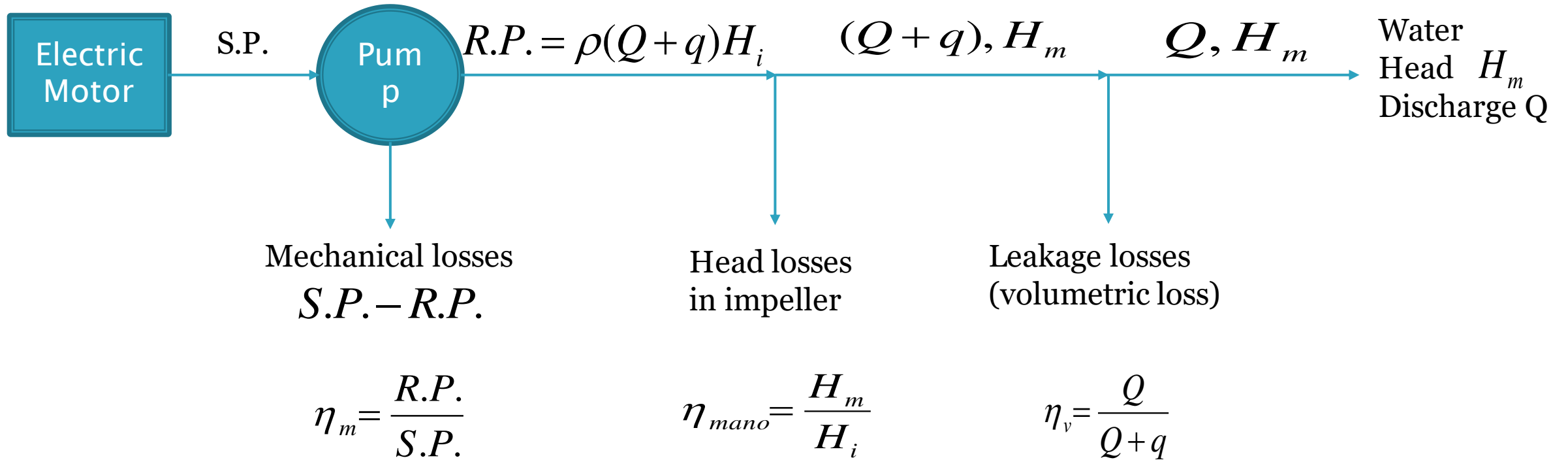
$$H = h_s + h_{fs} + h_d + h_{fd} + \frac{V_d^2}{2g}$$

$$= H_{st} + h_f + \frac{V_d^2}{2g}$$

$$H_m = H + \frac{1}{2g} (V_s^2 - V_d^2)$$

When $V_s = V_d$
Hence $H_m = H$

Losses of pump



Various losses in pumps

There are basically three types of losses occurs in centrifugal pumps.

1. Hydraulic losses

- Friction losses in the impeller.
- Shock or eddy losses at inlet to outlet of impeller.
- Friction and eddy losses in the diffuser or guide vanes and casing.
- Friction losses in suction and delivery pipes.

2. Mechanical losses

- Losses due to friction between liquid and impeller in space between impeller and casing
- Losses due to friction between different parts like bearing, glands packing etc.

3. Leakage losses

- Loss of energy due to pressure difference between liquid inside the pump and atmosphere.

EFFICIENCIES OF PUMP

1. Hydraulic efficiency (η_h):-

$$\eta_h = \frac{\text{Pump's Total Head (H)}}{\text{Euler Head (H}_e)}$$

$$\eta_h = \frac{gH}{V_{w2}U_2}$$

The normal value varies between 60% – 90%

2. Manometric Efficiency (η_m):-

$$\eta_m = \frac{\text{Pump's Manometric Head (H}_m)}{\text{Work done by impeller per sec/unit weight (H}_i)}$$

$$\eta_m = \frac{gH_m}{V_{w2}U_2}$$

3. Volumetric efficiency (η_v):-

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

The normal value lies between 97% to 98%

4. Mechanical efficiency (η_m):-

$$\eta_m = \frac{\text{Power at impeller}}{\text{Power supplied to pump}} = \frac{R.P.}{S.P.}$$

$$\eta_m = \frac{\rho(Q + q)V_{w2}U_2}{P}$$

The normal value is 95% – 98%

4. Overall efficiency(η_o):-

$$\eta_o = \frac{\text{Water power}}{\text{Shaft power}} = \frac{\rho Q g H_m}{P}$$

$$\eta_o = \left(\frac{H_m}{\frac{V_{w2} U_2}{g}} \right) \times \frac{Q}{(Q + q)} \times \frac{\rho(Q + q)(V_{w2} U_2)}{P}$$

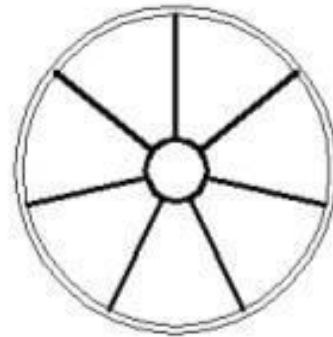
$$\eta_o = \eta_{mano} \times \eta_v \times \eta_m$$

The normal value is 71% – 86%

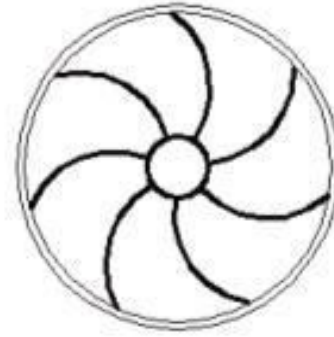
TYPES OF IMPELLER

There are three main categories of impeller due type of impeller's vane, which are used in the centrifugal pumps as;

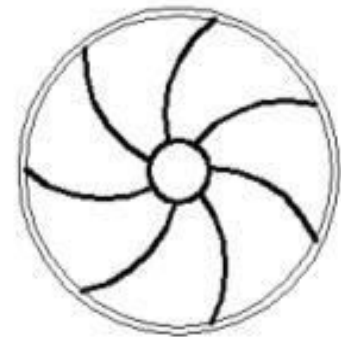
- Radial vanes, Fig. (a).
- Backward vanes, Fig. (b)
- Forward vanes, Fig. (c).



(a)



(b)

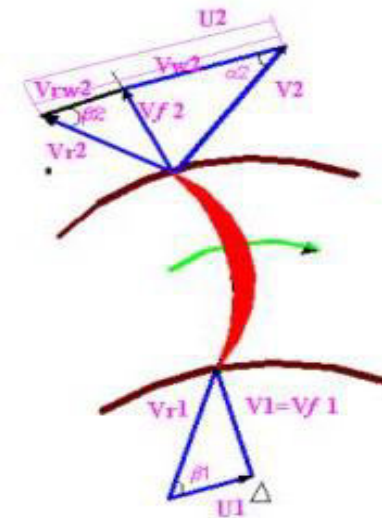
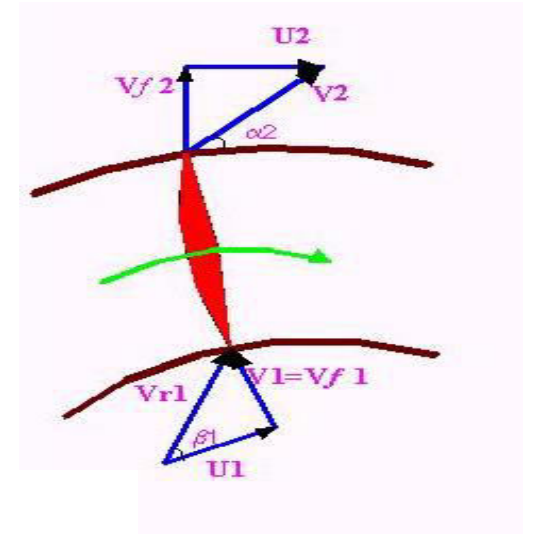
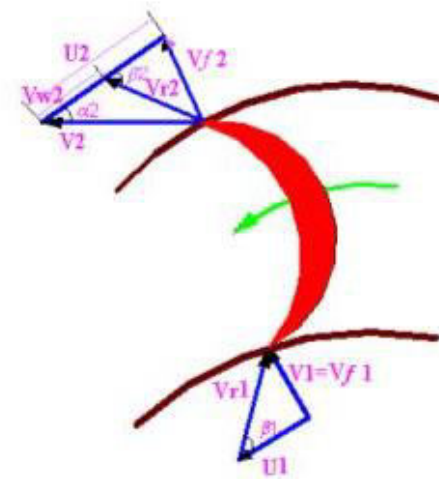


(c)

a) when $\beta_2 > 90^\circ$, the Forwards curved vanes of the impeller.

b) when $\beta_2 = 90^\circ$, the radial curved vanes of the impeller.

c) when $\beta_2 < 90^\circ$, the Backwards curved vanes of the impeller.



PRESSURE RISE THROUGH IMPELLER

- ▶ Applying energy equation between inlet and outlet of impeller

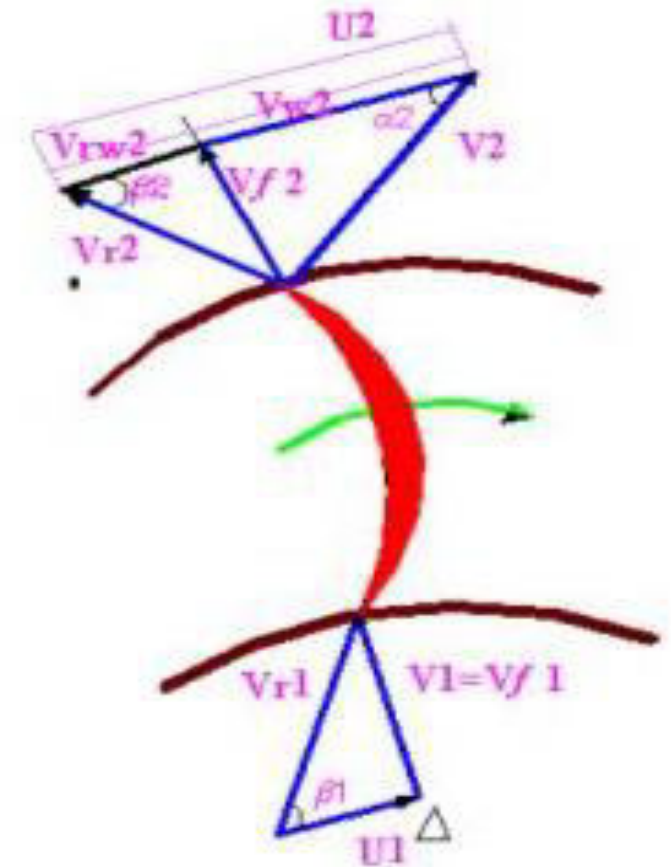
$$[Energy\ at\ input] + [Work\ input] = [Work\ output]$$

$$\therefore \left[\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + z_1 \right] + \left[\frac{V_{w2} u_2}{g} \right] = \left[\frac{p_2}{\rho g} + \frac{V_2^2}{2g} + z_2 \right]$$

Assu min $g \ z_1 = z_2$

$$\therefore \frac{p_1}{\rho g} + \frac{V_1^2}{2g} + \frac{V_{w2} u_2}{g} = \frac{p_2}{\rho g} + \frac{V_2^2}{2g}$$

$$\therefore \frac{p_2 - p_1}{\rho g} = \frac{1}{2g} [V_1^2 - V_2^2 + 2V_{w2} u_2] \dots\dots\dots (1)$$



► From outlet velocity triangle,

$$\therefore \tan \beta_2 = \frac{V_{f2}}{u_2 - V_{w2}} \quad \therefore u_2 - V_{w2} = \frac{V_{f2}}{\tan \beta_2} \quad \therefore V_{w2} = u_2 - V_{f2} \cot \beta_2$$

$$\begin{aligned} \text{Also, } V_2^2 &= V_{w2}^2 + V_{f2}^2 = (u_2 - V_{f2} \cot \beta_2)^2 + V_{f2}^2 \\ &= u_2^2 + V_{f2}^2 \cot^2 \beta_2 - 2u_2 V_{f2} \cot \beta_2 + V_{f2}^2 \\ &= u_2^2 + (1 + \cot^2 \beta_2) V_{f2}^2 - 2u_2 V_{f2} \cot \beta_2 \end{aligned}$$

The expression of V_{w2} and V_2 are putting in equation (1) we get

$$\frac{p_2 - p_1}{\rho g} = \frac{1}{2g} \left[V_1^2 - u_2^2 - (1 + \cot^2 \beta_2) V_{f2}^2 + 2u_2 V_{f2} \cot \beta_2 + 2(u_2 - V_{f2} \cot \beta_2) u_2 \right]$$

$$= \frac{1}{2g} \left[V_1^2 - u_2^2 - \operatorname{cosec}^2 \beta_2 V_{f2}^2 + 2u_2 V_{f2} \cot \beta_2 + 2u_2^2 - 2u_2 V_{f2} \cot \beta_2 \right]$$

$$\therefore \frac{p_2 - p_1}{\rho g} = \frac{1}{2g} \left[V_1^2 - V_{f2}^2 \operatorname{cosec}^2 \beta_2 + u_2^2 \right] \dots\dots\dots(2)$$

- ▶ For radial entry of liquid at inlet of impeller $V_1 = V_{f1}$

$$\therefore \frac{p_2 - p_1}{\rho g} = \frac{1}{2g} [V_{f1}^2 - V_{f2}^2 \cos^2 \beta_2 + u_2^2]$$

$$\therefore \text{Pressure rise in impeller} = \frac{p_2 - p_1}{\rho g} = \frac{1}{2g} [V_1^2 - V_{f2}^2 \cos^2 \beta_2 + u_2^2] \dots\dots\dots(3)$$

- The above expression has been derived by neglecting gravitational effects, frictional losses and assuming radial entry of liquid.

MINIMUM SPEED FOR STARTING A CENTRIFUGAL PUMP

- When the pump is switched on, the flow of water will not take until the rise in pressure through the impeller is large enough to overcome the manometric head. At the time of start, the fluid velocities are zero, and head due to change of kinetic energy into pressure energy is not available. As we know that a centrifugal head caused by the centrifugal force on the rotating water will be $\frac{u_2^2 - u_1^2}{2g}$. In other words, there will be flow of liquid only when the speed of the pump is such that the requires centrifugal head $\frac{u_2^2 - u_1^2}{2g}$ is sufficient to overcome the manometric head H_m .

▶ Hence flow will commence only if $\frac{u_2^2 - u_1^2}{2g} \geq H_m$

$$\therefore \frac{\left(\frac{\Pi D_2 N}{60}\right)^2 - \left(\frac{\Pi D_1 N}{60}\right)^2}{2g} \geq H_m \quad \therefore \left(\frac{\Pi N}{60}\right)^2 (D_2^2 - D_1^2) \geq 2gH_m \quad \dots (1)$$

$$\therefore N^2 \geq \frac{2gH_m \times 3600}{\Pi^2 (D_2^2 - D_1^2)} \quad \therefore N \geq \frac{84.59 \sqrt{H_m}}{\sqrt{D_2^2 - D_1^2}}$$

$$\therefore N_{\min} = 84.59 \sqrt{\frac{H_m}{D_2^2 - D_1^2}}$$

But, $H_m = \frac{V_{w2} u_2}{g} \times \eta_{mano}$

$$= \frac{V_{w2}}{g} \times \frac{\Pi D_2 N}{60} \times \eta_{mano}$$

► Therefore equation (1) becomes

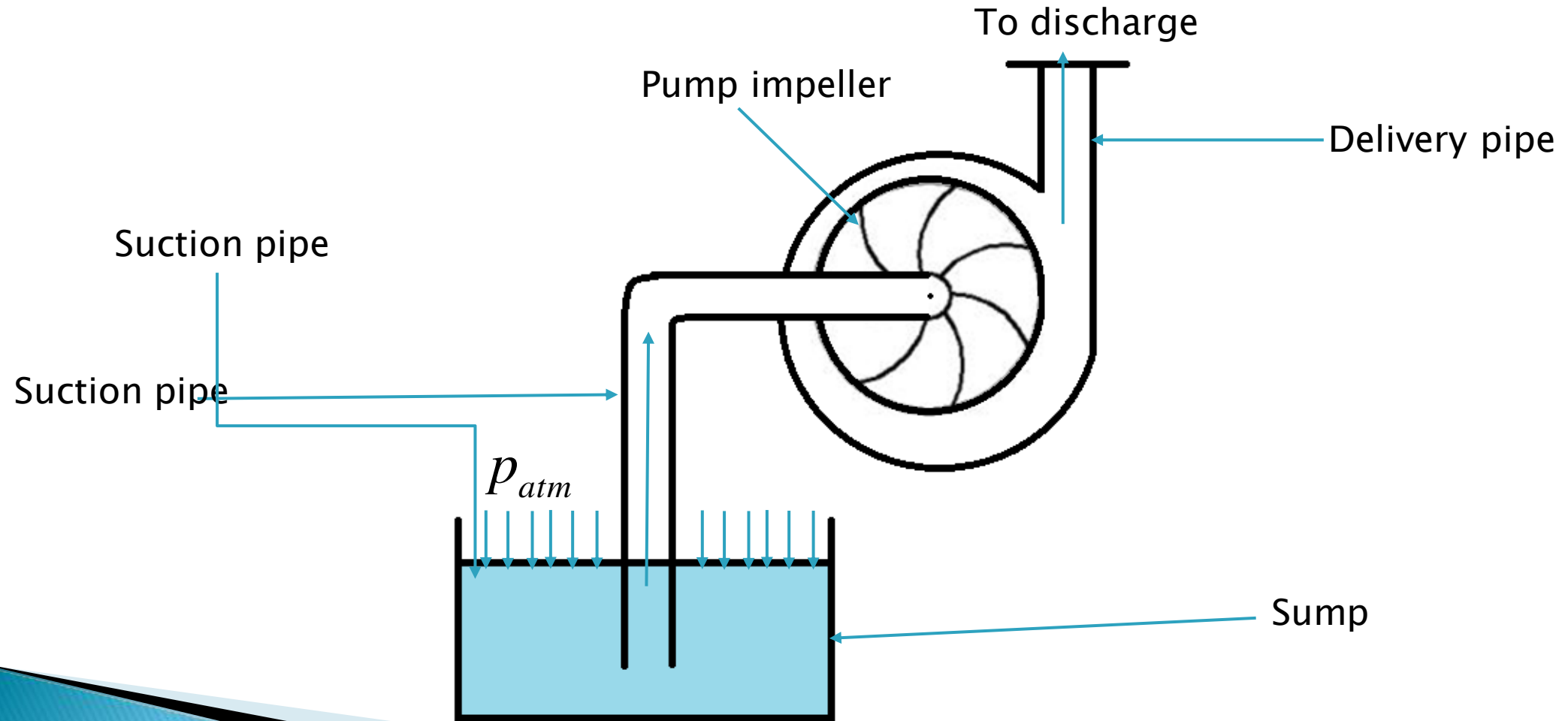
$$\therefore \left(\frac{\Pi N}{60} \right)^2 (D_2^2 - D_1^2) \geq 2g \left(\frac{V_{w2}}{g} \times \frac{\Pi D_2 N}{60} \times \eta_{mano} \right)$$

$$\therefore \left(\frac{\Pi N}{60} \right) (D_2^2 - D_1^2) \geq 2V_{w2} D_2 \times \eta_{mano}$$

$$\therefore N \geq \frac{120 \eta_{mano} \times V_{w2} \times D_2}{\Pi (D_2^2 - D_1^2)}$$

$$N_{\min} = \frac{120 \eta_{mano} \times V_{w2} \times D_2}{\Pi (D_2^2 - D_1^2)} \dots \dots \dots (2)$$

MAXIMIM SUCTION LIFT OR SUCTION HEIGHT



- ▶ Consider a centrifugal pump as shown in fig. which lifts a liquid from a sump. The free surface of liquid is at a depth of h_s below the center of impeller.
- ▶ Applying energy equation at free surface of liquid and inlet of impeller,

$$\frac{p_{atm}}{\rho g} + \frac{V_{atm}^2}{2g} + z_{atm} = \frac{p_1}{\rho g} + \frac{V_1^2}{2g} + z_1 + h_{fs}$$

where, p_{atm} = atmospheric pressure on free surface of liquid .

V_{atm} = velocity of liquid at free surface = 0

z_{atm} = height of free surface from datum = 0

p_1 = pressure at inlet of pump.

z_1 = height of inlet of pump from datum = h_s

V_1 = velocity of liquid at inlet of pump = V_s

h_{fs} = head loss in suction pipe.

$$\frac{p_{atm}}{\rho g} = \frac{p_1}{\rho g} + \frac{V_s^2}{2g} + h_s + h_{fs} \left(\because V_{atm} = 0, z_{atm} = 0, V_1 = V_s, z_1 = h_s \right)$$

$$\frac{p_1}{\rho g} = \frac{p_{atm}}{\rho g} - \left(\frac{V_s^2}{2g} + h_s + h_{fs} \right)$$

➤ For maximum suction lift $p_1 = p_v$

$$\therefore \frac{p_v}{\rho g} = \frac{p_{atm}}{\rho g} - \left(\frac{V_s^2}{2g} + h_s + h_{fs} \right)$$

But $\frac{p_v}{\rho g} = \text{vapour pressure head} = H_v$

$\frac{p_{atm}}{\rho g} = \text{atmospheric pressure head} = H_{atm}$

$$\therefore H_v = H_{atm} - \frac{V_s^2}{2g} - h_s - h_{fs}$$

$$\therefore h_s = H_{atm} - H_v - h_{fs} - \frac{V_s^2}{2g}$$

- ▶ Above equation is a **maximum suction lift or height**. If the suction height of pump is more than h_s , there is possibility of cavitation.

NET POSITIVE SUCTION HEAD (NPSH)

- ▶ The term NPSH is commonly used in pump industry b'coz the minimum suction conditions are specified in terms of NPSH.

- ▶ $NPSH = [\text{Absolute pressure head at inlet of pump}]$
 $- [\text{Vapour pressure head}]$
 $+ [\text{Velocity head at inlet of pump}]$

$$= \frac{p_1}{\rho g} - \frac{p_v}{\rho g} + \frac{V_s^2}{2g}$$

$$\text{But, } \frac{p_1}{\rho g} = \frac{p_{atm}}{\rho g} - \left(\frac{V_s^2}{2g} + h_s + h_{fs} \right)$$

$$\begin{aligned}
\therefore NPSH &= \frac{P_{atm}}{\rho g} - \frac{V_s^2}{2g} - h_s - h_{fs} - \frac{P_v}{\rho g} + \frac{V_s^2}{2g} \\
&= H_{atm} - H_v - h_s - h_{fs} \\
\therefore NPSH &= [H_{atm} - h_s - h_{fs}] - H_v \\
\therefore NPSH &= [Total\ suction\ head]
\end{aligned}$$

NPSH may defined as total head required to make liquid flow through suction pipe to impeller of pump.

For cavitation free operation of centrifugal pump, **available NPSH > required NPSH**

CAVITATION IN CENTRIFUGAL PUMP

- ▶ In centrifugal pump pressure is lowest at the inlet of impeller and hence vapour bubbles are formed in the suction region.
- ▶ These bubbles are carried along with the flowing liquid to higher pressure region near the exit of impeller where these vapour bubbles condense and bubbles collapse.
- ▶ Due to sudden collapsing of bubbles on metallic surface the high pressure is created, which cause pitting action on metallic surface and produces much noise and vibrations.

❑ Factors make tendency of cavitation

- High impeller speed
- Small diameter of suction pipe and inlet of impeller
- Too high specific speed
- High temperature of flowing fluid
- Required NPSH \geq available NPSH

❑ Cavitation effect in centrifugal pump is avoided/minimized by

- Maintaining low velocity of liquid in suction pipe
- Keeping low temperature of flowing liquid to keep vapour pressure down and to obtain larger available NPSH
- Using suction pipe without sharp bends to reduce loss of head.

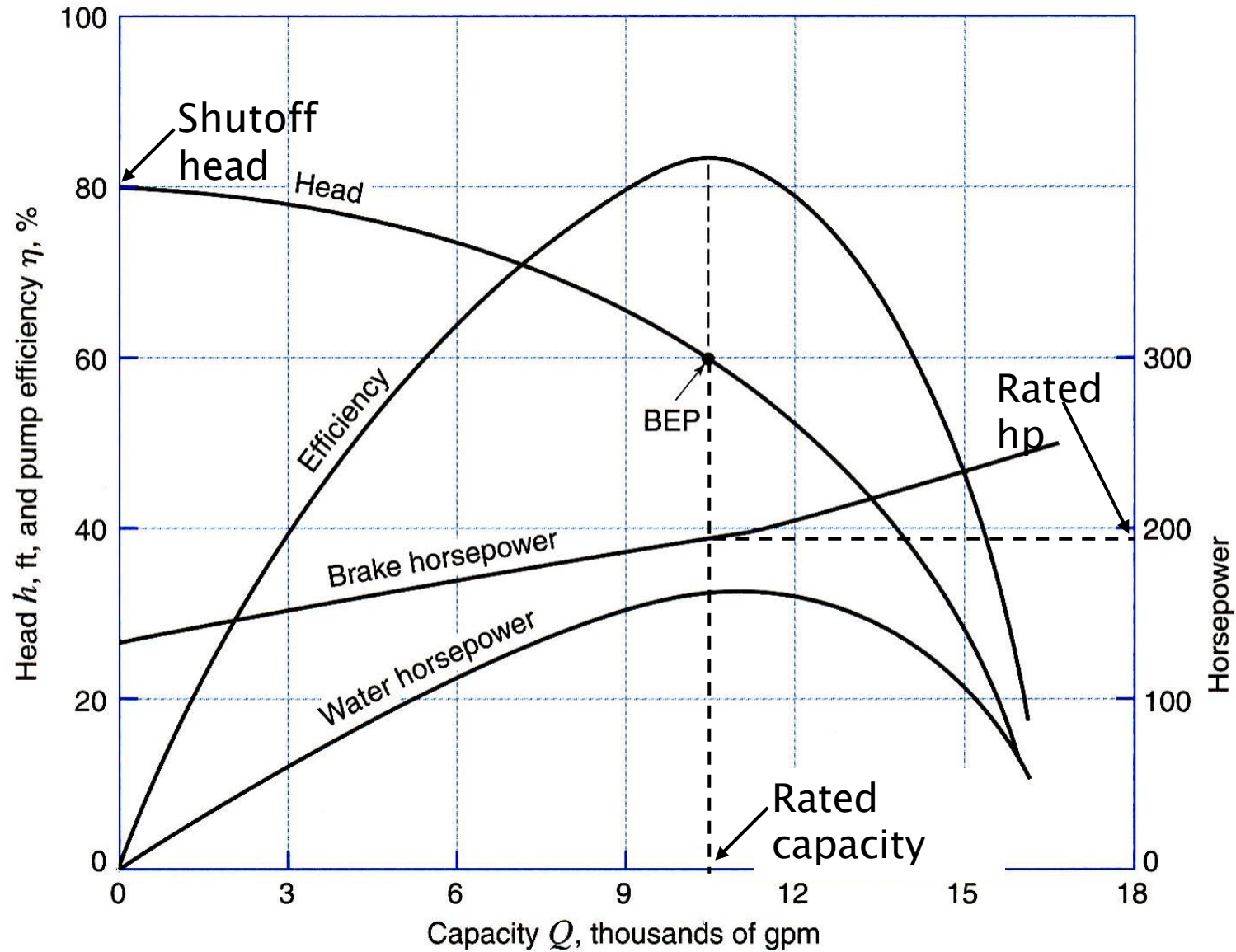
- ▶ In order to determine whether cavitation will occur in any portion of the suction side of the pump, the critical value of Thoma's cavitation factor (σ_c) is calculated.

$$\sigma_c = \frac{(H_{atm} - H_v) - H_v - h_{fs}}{H_m} = \frac{NPSH}{H_m}$$

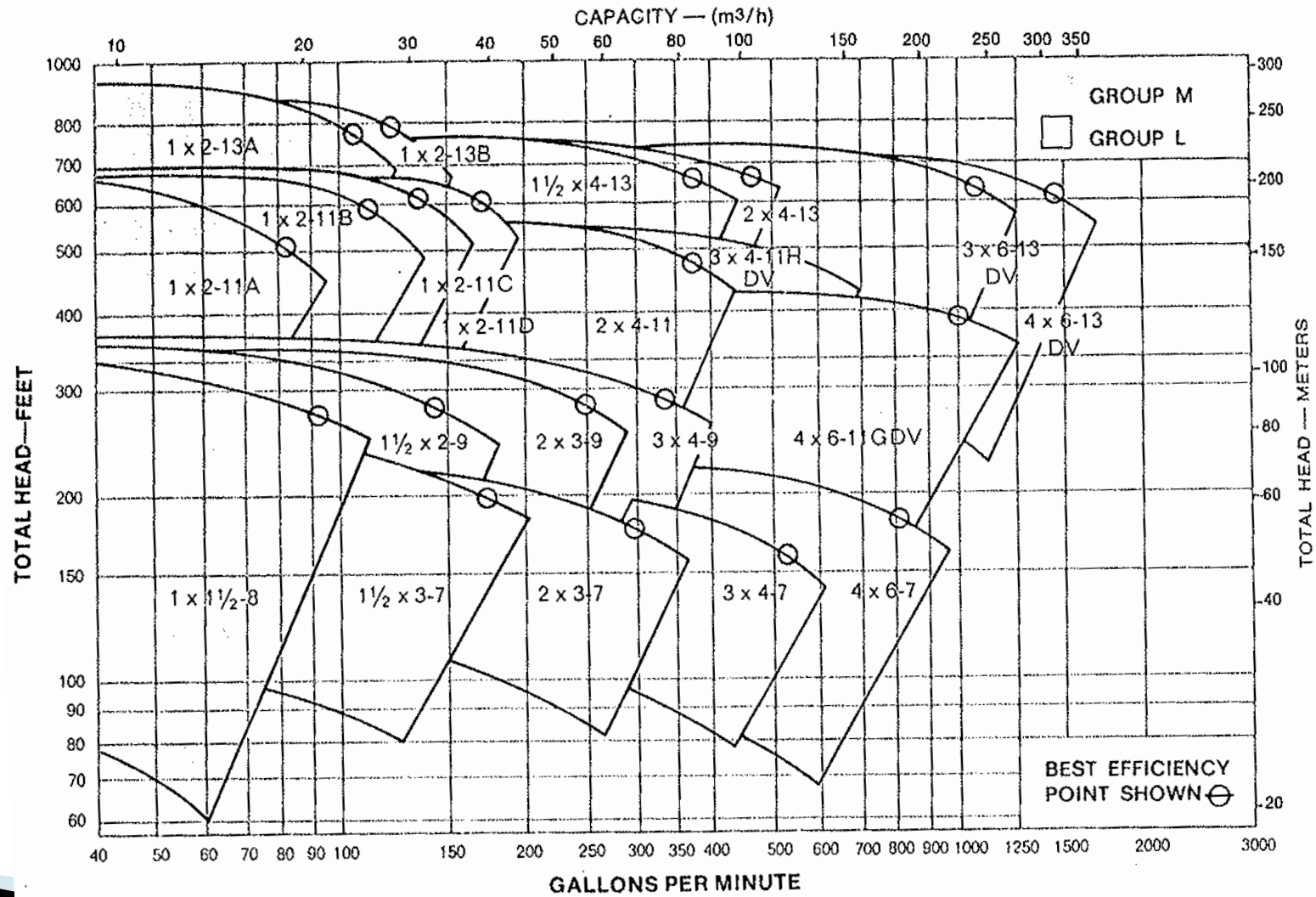
PUMP SELECTION

- ▶ Pump curve – indicates TDH provided by the pump as a function of Q ;
 - Depends on particular pump; info usually provided by manufacturer
 - TDH at zero flow is called the ‘shutoff head’
- ▶ Pump efficiency
 - Can be plotted as $\text{fun}(Q)$, along with pump curve, on a single graph
 - Typically drops fairly rapidly on either side of an optimum; flow at optimum efficiency known as “normal” or “rated” capacity
 - Ideally, pump should be chosen so that operating point corresponds to nearly peak pump efficiency (‘BEP’, best efficiency point)

Pump Performance and Efficiency Curves

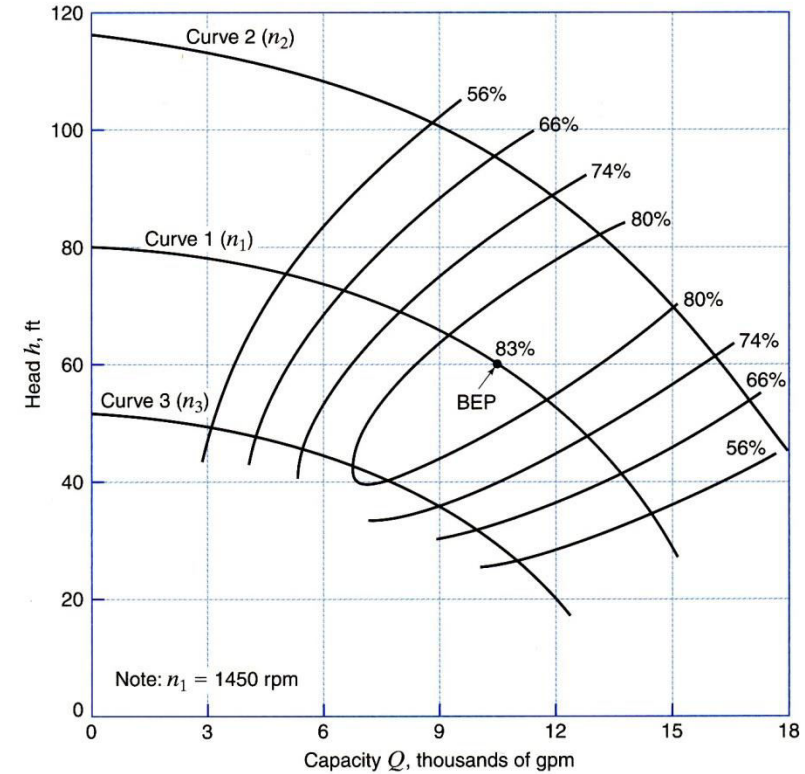
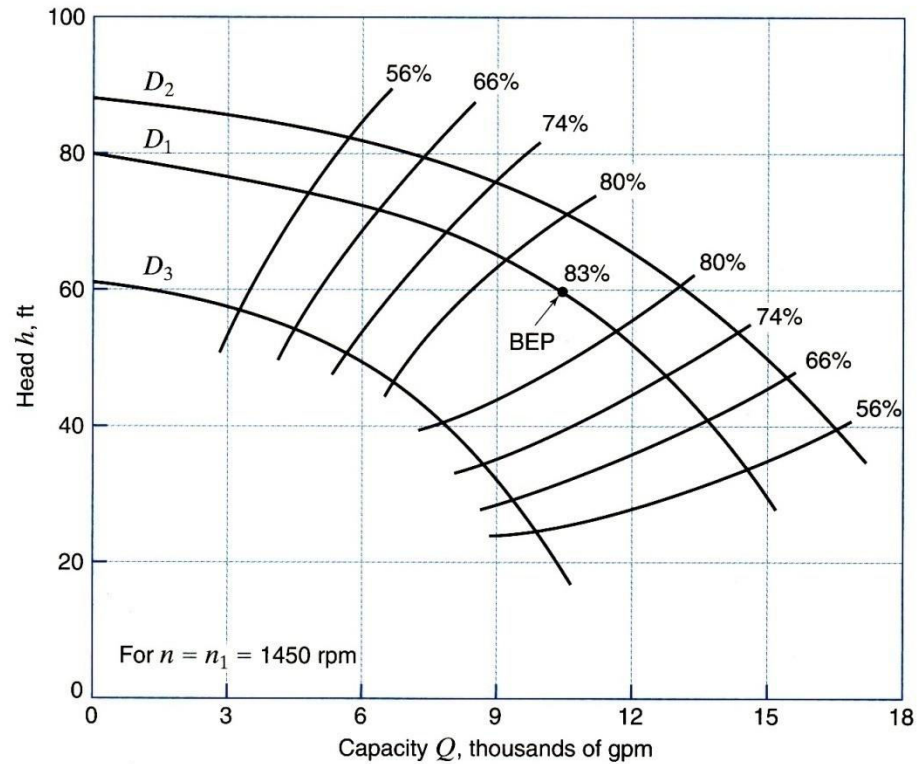


Pump Selection



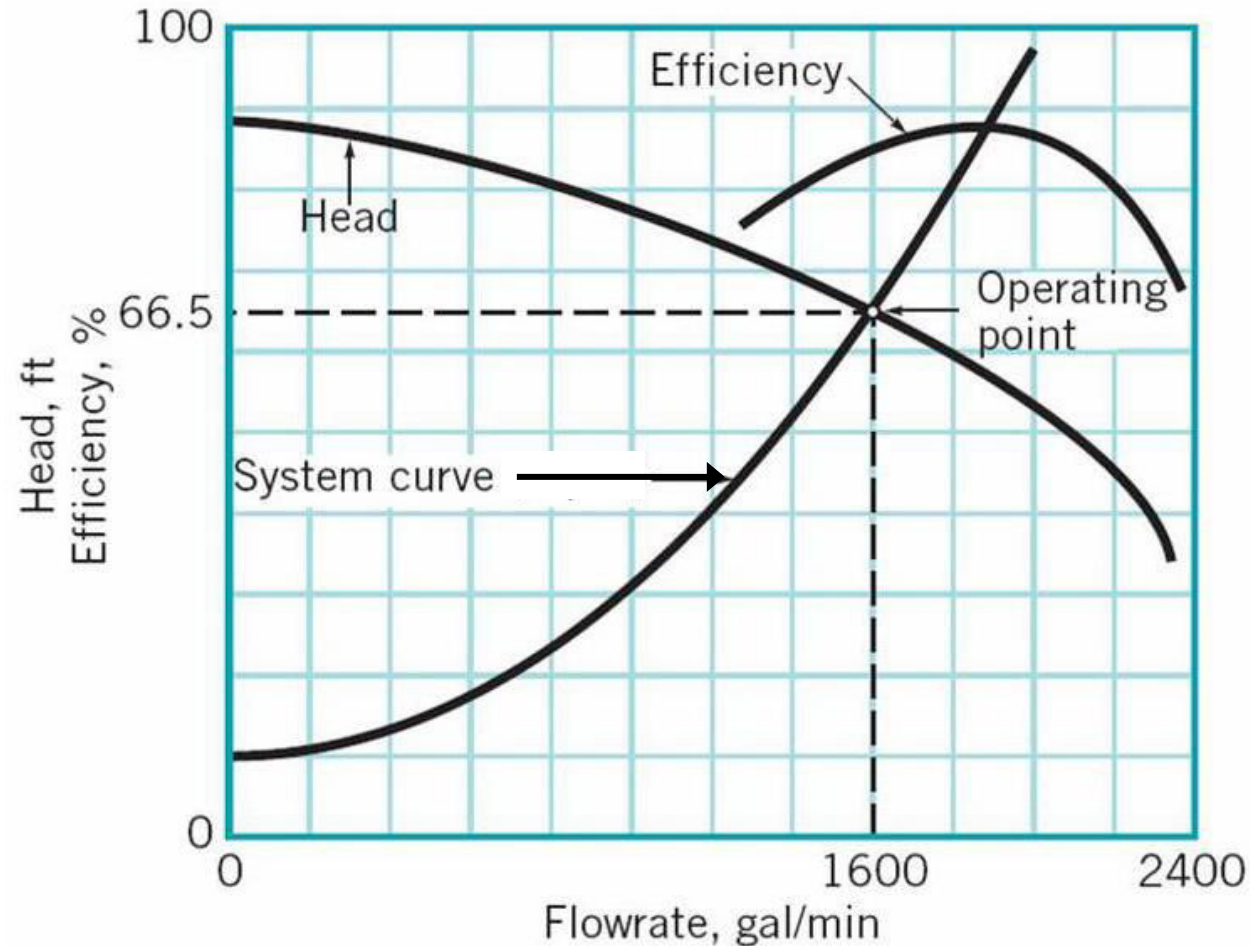
Pump Efficiency

- ▶ Pump curves depend on pump geometry (impeller D) and speed



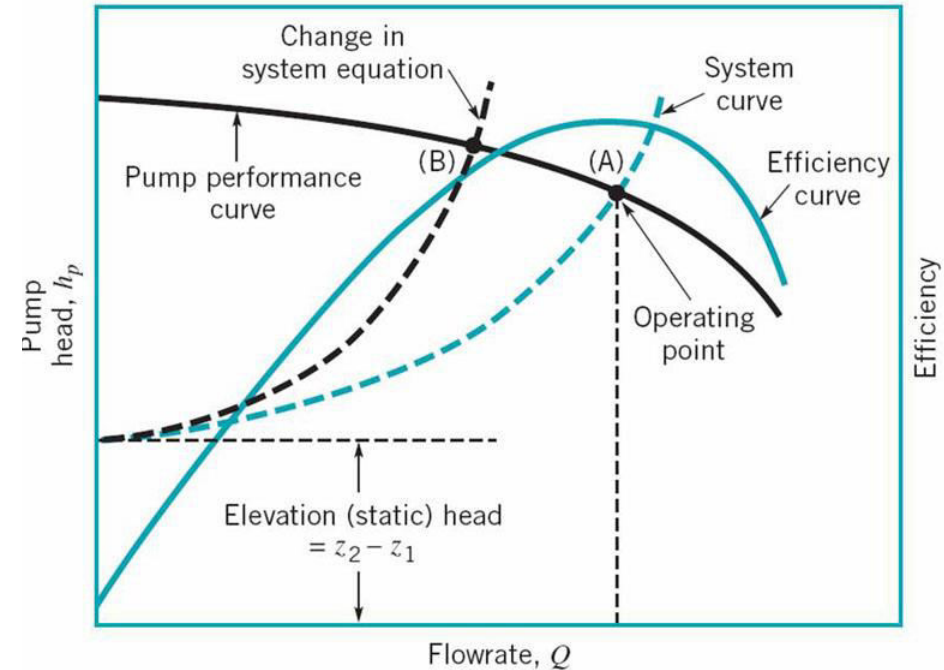
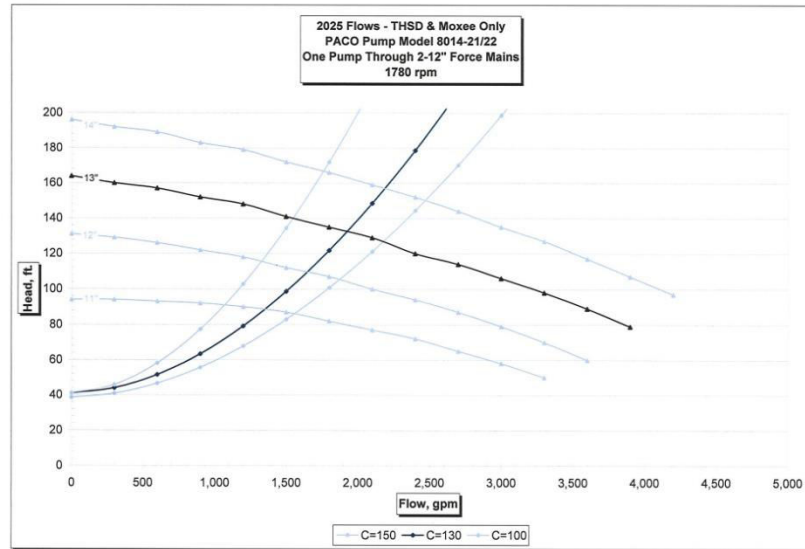
Pump Selection

- ▶ At any instant, a system has a single Q and a single TDH, so both curves must pass through that point; → operating point is intersection of system and pump curves



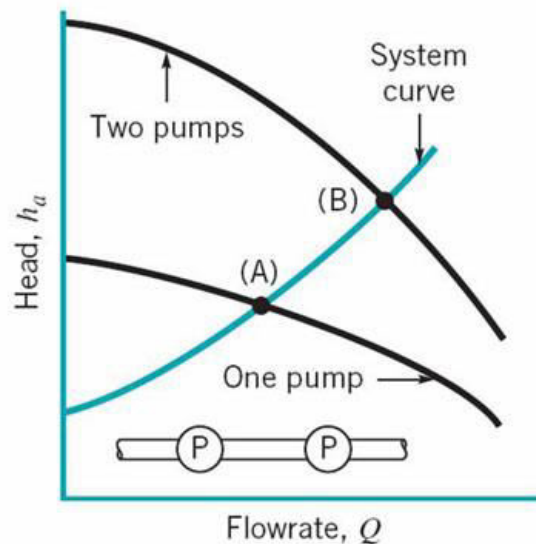
Pump System Curve

- System curve may change over time, due to fluctuating reservoir levels, gradual changes in friction coefficients, or changed valve settings.

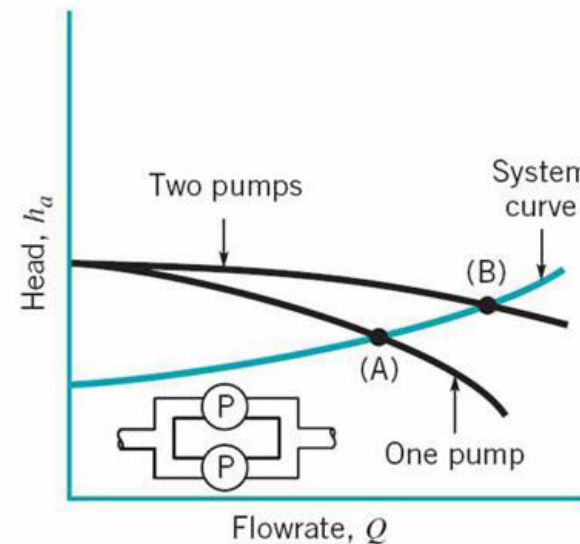


Pump Selection: Multiple Pumps

- ▶ Pumps often used in series or parallel to achieve desired pumping scenario
- ▶ In most cases, a backup pump must be provided to meet maximum flow conditions if one of the operating ('duty') pumps is out of service.
- ▶ Pumps in series have the same Q , so if they are identical, they each impart the same TDH, and the total TDH is additive
- ▶ Pumps in parallel must operate against the same TDH, so if they are identical Q is additive



(a)

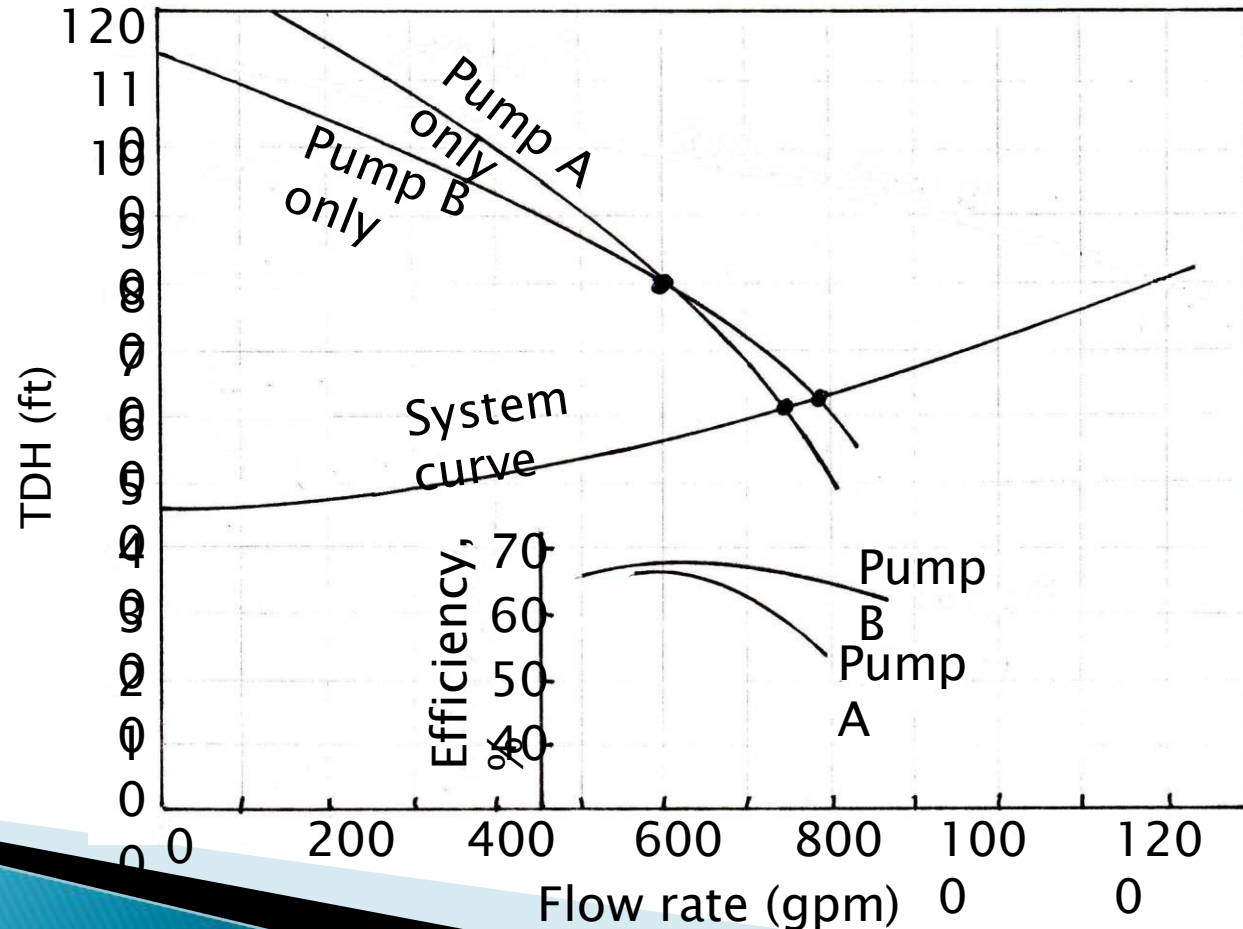


(b)

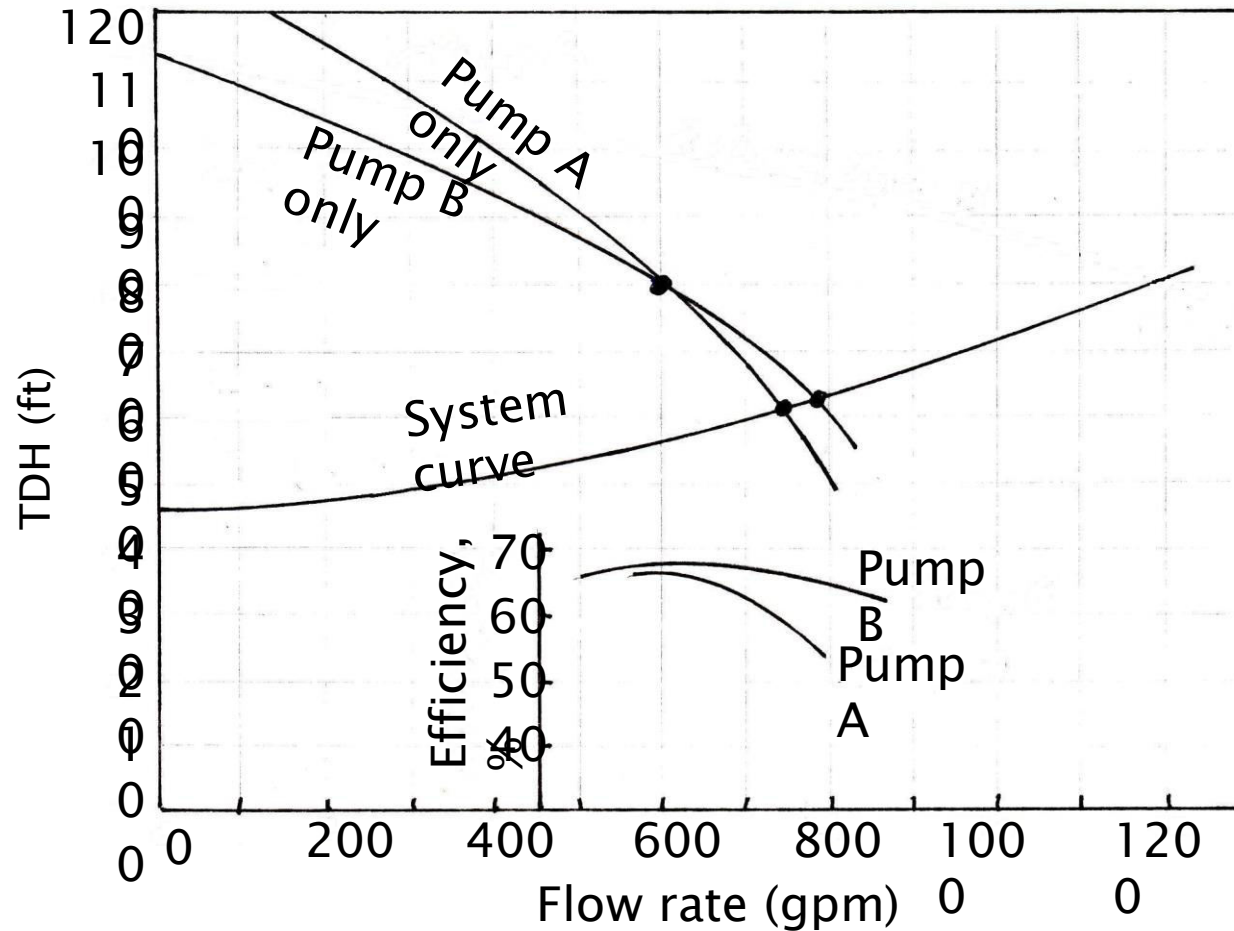
Q is additive

Adding a second pump moves the operating point "up" the system curve, but in different ways for series and parallel operation

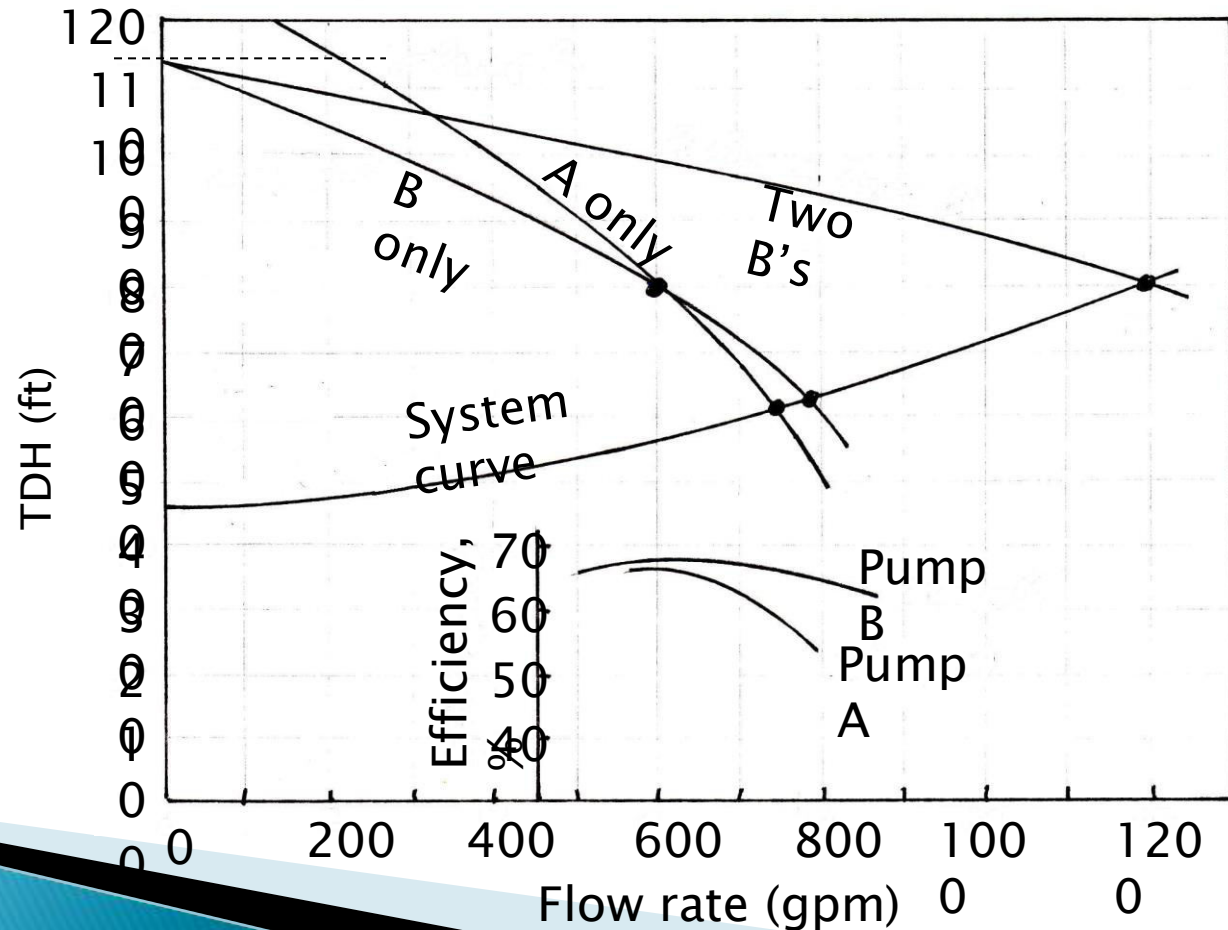
Example. A pump station is to be designed for an ultimate Q of 1200 gpm at a TDH of 80 ft. At present, it must deliver 750 gpm at 60 ft. Two types of pump are available, with pump curves as shown. Select appropriate pumps and describe the operating strategy. How will the system operate under an interim condition when the requirement is for 600 gpm and 80-ft TDH?



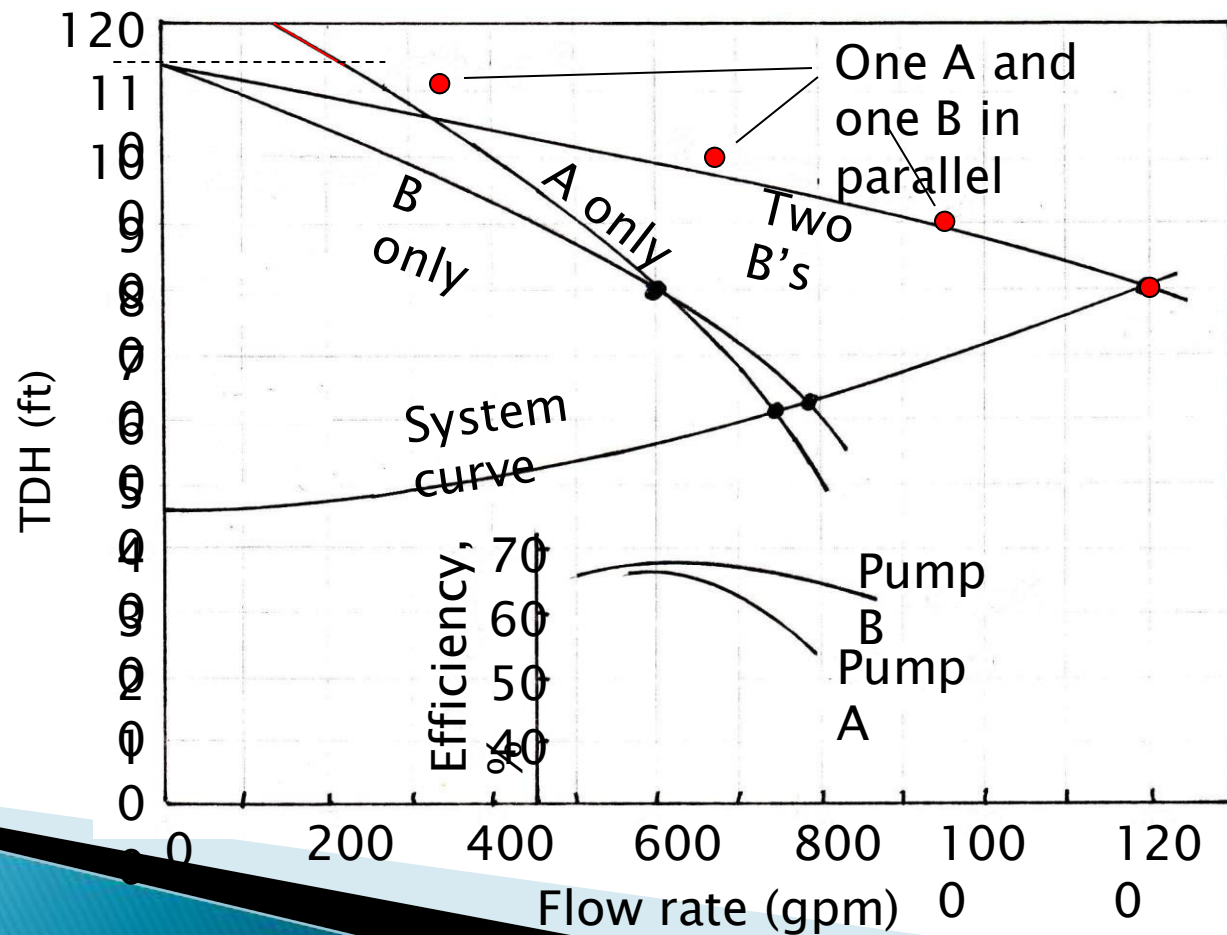
Either type of pump can meet current needs (750 gpm at 60 ft); pump B will supply slightly more flow and head than needed, so a valve could be partially closed. Pump B has higher efficiency under these conditions, and so would be preferred.



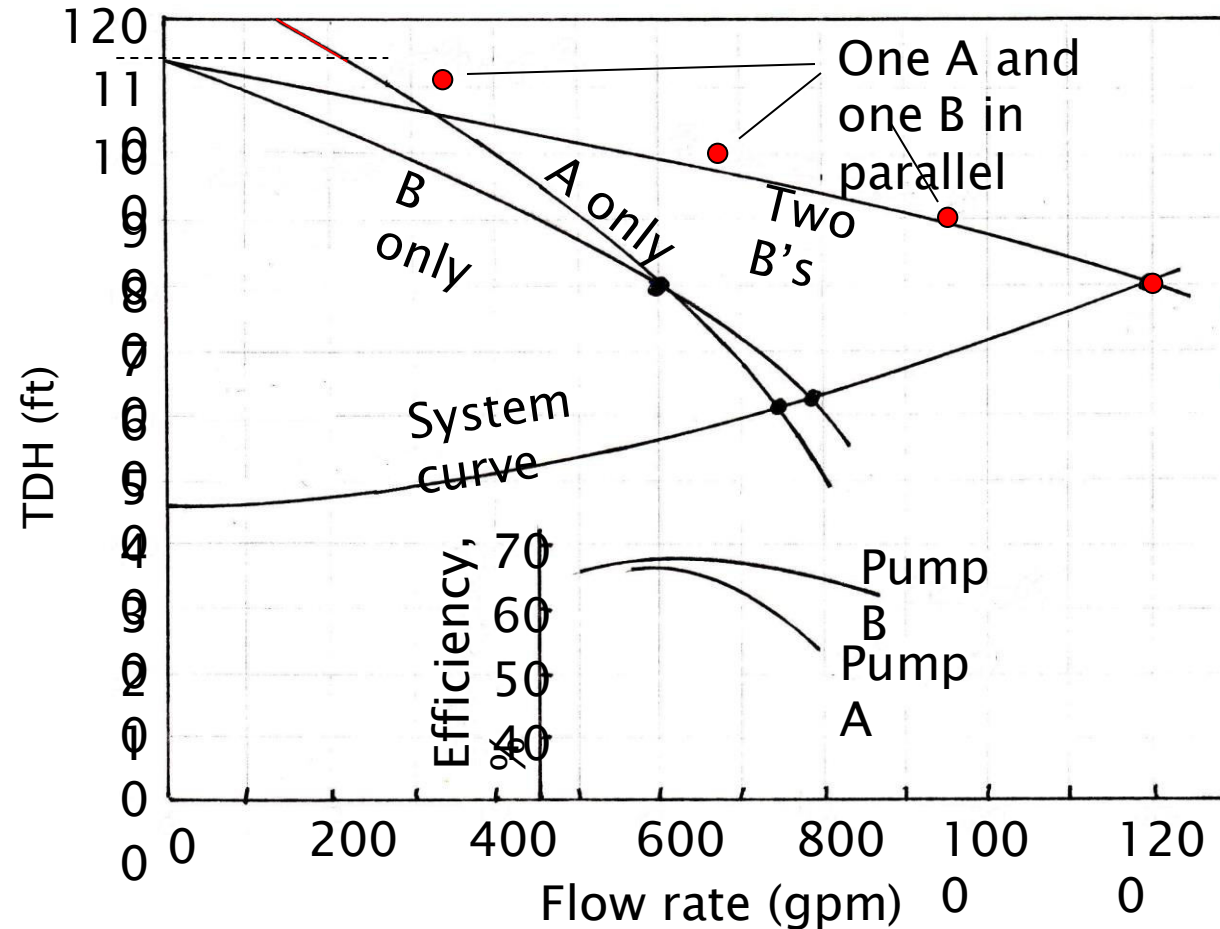
The pump characteristic curve for two type-B pumps in parallel can be drawn by taking the curve for one type-B pump, and doubling Q at each value of TDH. Such a scenario would meet the ultimate need (1200 gpm at 80 ft), as shown below.



A pump characteristic curve for one type-A and one type-B pump in parallel can be drawn in the same way. This arrangement would also meet the ultimate demand. Note that the type-B pump provides no flow at $TDH > 113$ ft, so at higher TDH, the composite curve is identical to that for just one type-A pump. (A check valve would prevent reverse flow through pump B.) Again, since type B is more efficient, two type-B pumps would be preferred over one type-A and one type-B.



At the interim conditions, a single type B pump would suffice.
A third type B pump would be required as backup.



PRIMING

- ▶ The operation of filling the casing , impeller and suction pipe and the portion of delivery pump up to delivery valve is called priming.
- ▶ In case the priming of pump is not done and the pump is not done and the pump is not under the operation, the water present in the pump and suction pipe will flow back to the sump. The space occupied by water will be filled by air.

- ▶ If the pump is now started, the air pockets inside the impeller may give rise to vortices and cause the discontinuity of flow. Under these condition, the flow of fluid does not commence and the pump runs dry. It causes the rubbing and seizing of the wearing rings, increases noise level and vibrations and finally may cause the serious damage to pump.
- ▶ The priming in reciprocating pumps is not required since the pumping is done by positively moving the fluid out of the cylinder by the piston. Hence, the air will be displaced from the casing when the pump starts and it will get a suction pressure which will draw the fluid from the sump.

- Priming for small pumps is done by hand
- A foot valve is essential at the bottom of suction pipe
- A funnel or priming cup is provided to fill the water by hand. An air vent is provided in the casing of pump. When the water is filled, the air escapes through the air vent. It is closed once the priming is completed