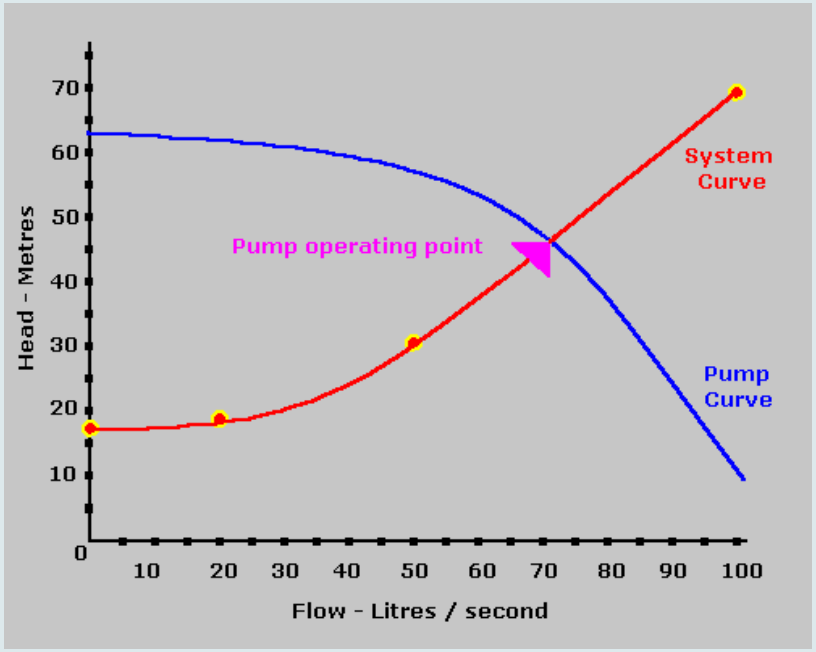
Why is the operating point or (operating discharge) of a centrifugal pump called point of maximum discharge?

Operating point or duty point is obtained from the intersection between pipe system curve and pump performance curve when the discharge pipe is fully open. That means no more flow can be delivery for this particular pipe system curve. At this point, the pump may not be working at its best efficiency.



Differentiate between shaft horsepower and brake horsepower.

Shaft horsepower is how much horsepower it takes a pump to pump a specific amount of water. Brake horsepower is the measure of a pump's horsepower without the loss in power.

$$Shaft\ hp = \frac{\gamma QH}{\eta}$$

$$Brake\ hp = \frac{2\pi N}{60} T$$

Why is it preferable to use relatively large pipe sizes for the suction lines in pumping systems?

Using large diameter pipes at the inlet of the pump will minimize frictional losses at the inlet. Thus the pressure drop at the inlet of the pump will be minimized and consequently cavitation will be avoided.

What is meant by B.E.P?

The highest efficiency of a pump occurs at the flow where the incidence angle of the fluid entering the hydraulic passages best matches with the blade angle. The operating condition where a pump design has its highest efficiency is referred to as the best efficiency point B.E.P. All points to the right or left of B.E.P have a lower efficiency. The most stable area is near or at the B.E.P.

Differentiate briefly between cavitation and air entraining vortices.

In short, the major difference between cavitation and air entraining vortices is that cavitation is a problem related to the suction pressure and the evaporation of water inside the pump while air entraining vortices is due to the decrease of water level in the supply reservoir which will allow air to enter the pump and consequently may block the operation of the pump.

What is N.P.S.H.?

The Net Positive Suction Head (N.P.S.H.) is the head at the suction flange of the pump less than the vapour pressure converted to fluid column height of the fluid. The N.P.S.H. is always positive since it is expressed in terms of absolute fluid column height. The term "Net" refers to the actual head at the pump suction flange and not the static head. The N.P.S.H. is independent of the fluid density.

What is the difference between the N.P.S.H. available and the N.P.S.H. required?

The N.P.S.H available can be calculated for a specific situation and depends on the barometric pressure, the friction loss between the system inlet and the pump suction flange, in addition to other factors. The N.P.S.H. required is given by the pump manufacturer and depends on the head, flow and type of pump. The N.P.S.H. available must always be greater than the N.P.S.H. required for the pump to operate properly.

What information do I need to order a centrifugal pump?

- total head
- flow rate
- fluid properties as temperature, pH,…etc

What is the best way to start a pump?

Starting the pump with a closed discharge valve is the best way to start a pump. Thus, the power absorbed by the pump will be minimized because this power will only be friction power.

What is meant by specific speed of the pump? And what is its unit?

Pump designers like to use specific speed (dimensionless numbers), because this allows them to analyze and compare pump performance regardless of size . Otherwise, how would you compare a 6" pump performance with a 10" pump? Also this value tells us something about the type of pump.

$$N_s = \frac{N.Q^{1/2}}{H^{3/4}}$$

What is meant by suction specific speed ?Does it change when the pump speed change?

Suction specific speed is a number that is dimensionally similar to the pump specific speed and is used as a guide to prevent cavitation.

While specific speed (N_S) is mostly related to the discharge side of the pump, the suction specific speed deals primarily with its suction (inlet) side. The head (H) term in the denominator of the defining formula for the N_S is substituted by the NPSHR:

The Hydraulic Institute recommends that the suction specific speed be limited to 8500 to avoid cavitation.

$$S = \frac{N \times gpm^{0.5}}{NPSH_R^{0.75}}$$

What is meant by unstable performance characteristic curve of a pump?

API 610 states that "…pumps that have stable head/capacity curves (continuous rise to shutoff) are preferred for all pumps applications .If the pump curve is stable, there is always a unique point ("A") – an intersection of a pump curve and a system curve. If the pump curve is unstable, the region between "B" and "F" has two possibilities – at either flow Q_b, or Q_f.

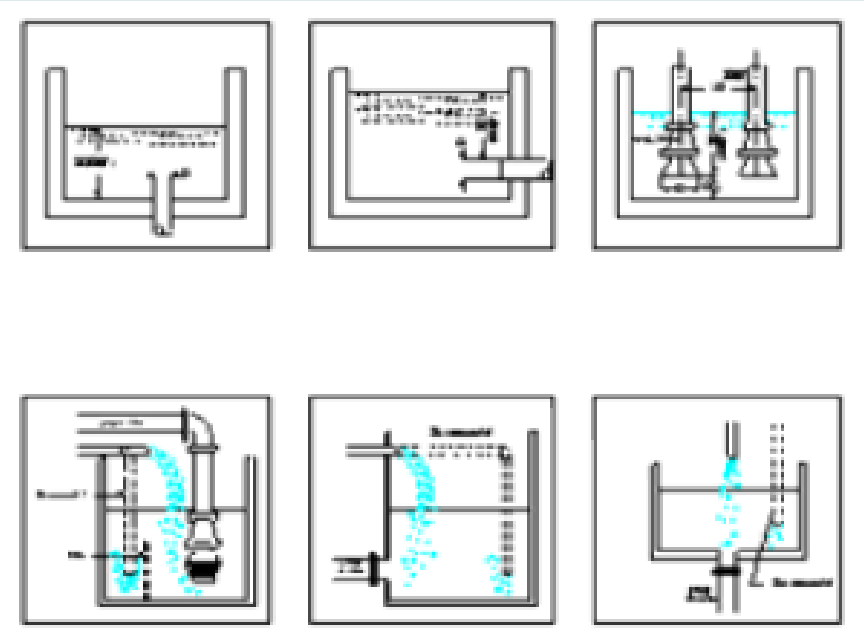
Stable curve (left) has a single definition of an intersection between a pump curve and a system curve. Unstable curve (right) has two flows where a pump can operate, at the same head.

How to keep air pockets in the suction pipe out of the pump?

- The suction pipe should be arranged with uniform slope upwards from the sump to the pump.
- Suction valves should be installed with the stem horizontal so that no air pockets are formed at the top of the valve.
- The gate valve should not be between the check valve and the pump.
- Make sure that the inlet of the suction pipe is well submerged in the sump
- Avoid the free fall of water at / or near the inlet of the suction pipe as this can be a reason for the appearance of air bubbles. All suction pipes should be well submerged.

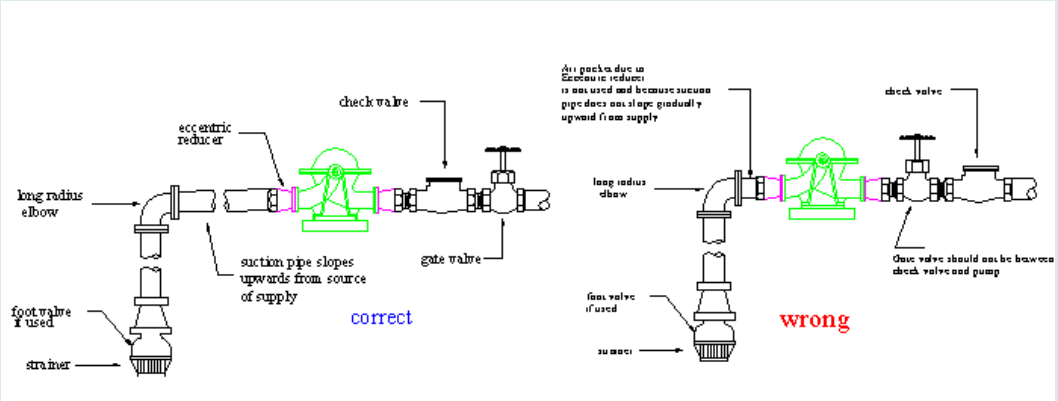
Explain with the help of neat sketch how air entraining vortices at the pump intake can be eliminated ?

It is recommend to use vortex breaker and also keep the submersible water high enough to prevent vortex formation.



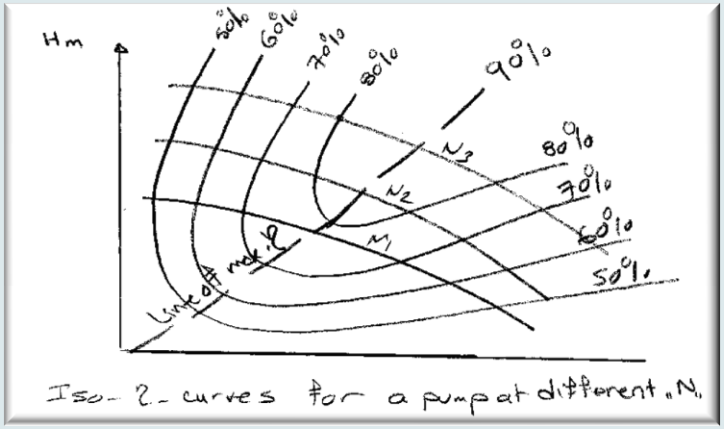
Is it right to locate the gate valve between the check valve and the pump or not ?

No as shown below the gate valve should be between the check valve and the pump so that to avoid air pocket formation in the pumping system



What is meant by pump iso-efficiency curve ?

As shown in the accompanied figure it is the line which connected the best efficiency points at different rpm of the pump.



What is the purpose of a variable speed drive?

All systems require a means of flow control. The plant's output requirements may change causing flow demand to vary and therefore the various systems throughout the process must be able to modify their output flow rate. To achieve this, pumps are sized for the maximum anticipated flow rate. The most frequent means of reducing the output flow rate is to have a line which re-circulates flow back to the suction tank. Another method is to have a valve in the discharge line which reduces the output flow rate when throttled. Either method works well, but there is a penalty to be paid in consumption of extra power for running a system which is oversized for the normal demand flow rate. A solution to this power waste is to use an electronic variable speed drive. For a new installation this alternative should be considered. This provides the same flow control as a valved system without energy waste.

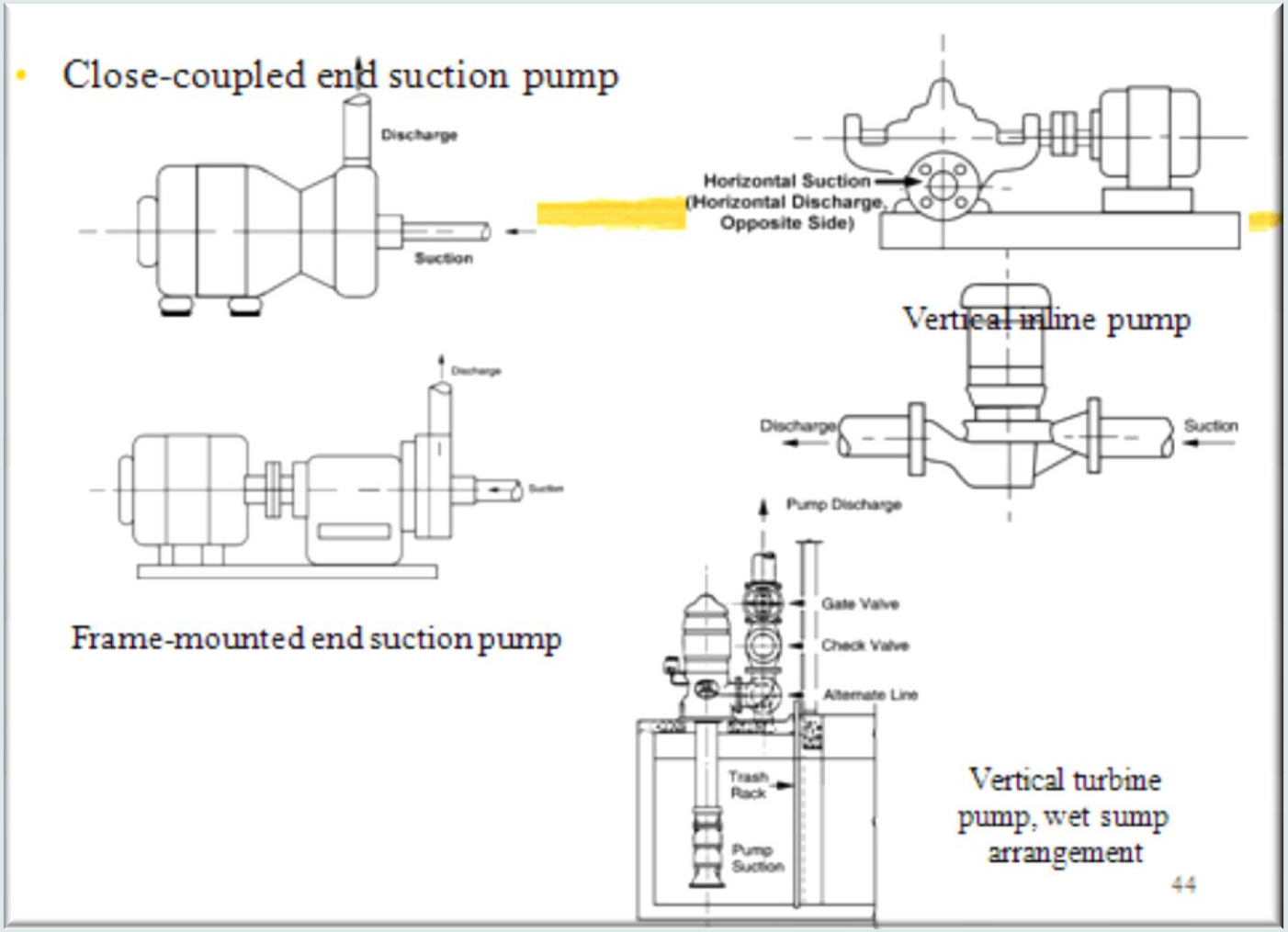
How does a variable speed drive work?

The head and flow produced by a pump is the result of centrifugal force imparted to the liquid by the impeller. Centrifugal force is directly proportional to impeller diameter and rotational speed. We can affect the centrifugal force by either changing the impeller diameter, which is difficult, or varying the impeller speed, which of course is what a variable speed drive does. The family of curves shown on pump performance charts corresponds to the performance of a pump at constant speed with various impeller sizes. If we keep the impeller size constant and vary the speed of the pump, a similar set of curves for different pump speeds is produced. Therefore, when a variable speed drive is used, only the required pump head and flow is produced resulting in an appropriate power consumption.

How can the same pump satisfy different flow requirements of a system?

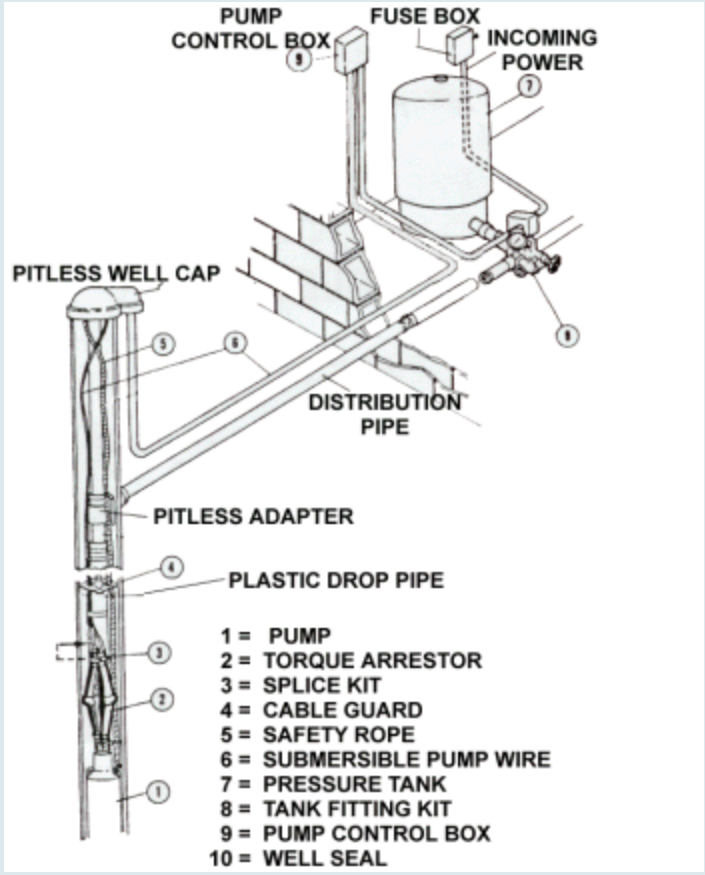
If a pump is sized for a greater flow and head that is required for the present conditions, then a manual valve at the outlet of the pump can be used to throttle the flow down to the present requirements. Therefore, at a future date the flow can be increased by simply opening a valve. This however is wasteful of energy and a variable speed drive should be considered.

Describe with the help of neat sketch the difference between closed-couple end suction pump, Frame-mounted end suction pump , Base-mounted horizontal split case pump ,Vertical inline pump and vertical turbine pump.



What do you understand by the term "submersible pumps"?

Submersible pumps are those pumps used in water wells. (pump is immersed in water).

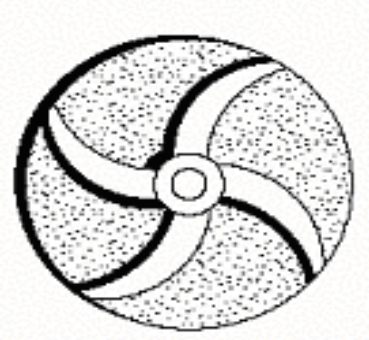


Differentiate between static Head & geodetic head in a pumping system.

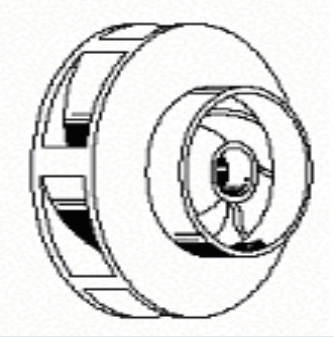
Static head is the vertical distance between water levels (that if we assume both reservoirs top and ground are infinite reservoirs i.e. there is no water level fluctuation due to pumping of water). Whereas the geodetic head term is used in water wells when the water level in the well drop sharply during the pumping operation.

Distinguish between semi-open impeller and open impeller & enclosed impeller pumps.

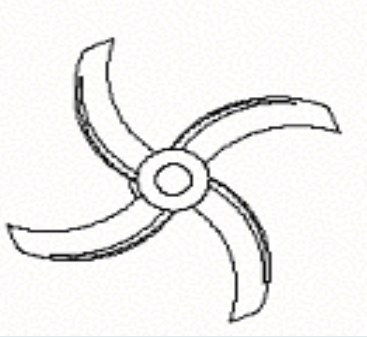
- The open impeller consists only of blades attached to a hub.
- The semi-open impeller is constructed with a circular plate (the web) attached to one side of the blades.
- The enclosed impeller has circular plates attached to both sides of the blades. Enclosed impellers are also referred to as shrouded impellers.



Enclosed impeller



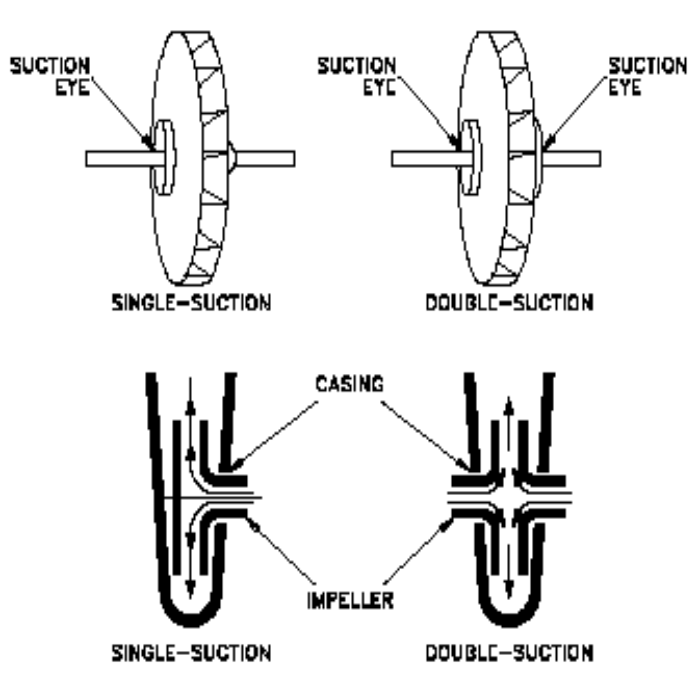
Semi-open impeller



Open impeller

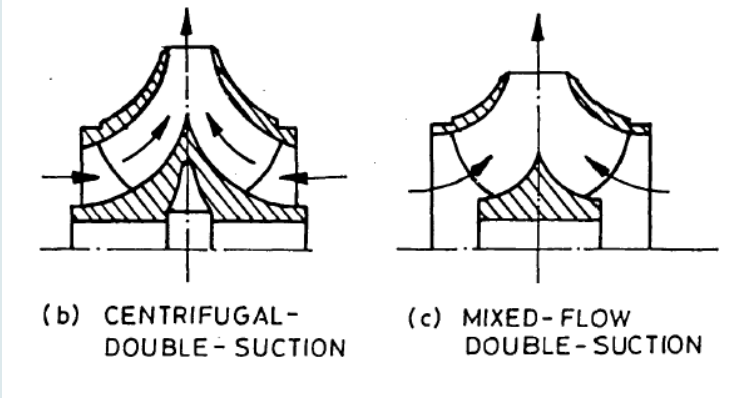
Distinguish between single suction impeller & double suction impeller pumps.

A single-suction impeller allows liquid to enter the center of the blades from only one direction. A double-suction impeller allows liquid to enter the center of the impeller blades from both sides simultaneously.



What benefit can we get from double suction pump?

Double-suction pumps are preferred in application over 1000 GPM because its very high efficiency heavy duty casings, and can be opened, inspected and serviced without disturbing the motor, impeller or the piping connections. The pump case can be split axially (parallel to the shaft) or vertically for servicing. This pump takes more floor space than end suction pumps and is more expensive.

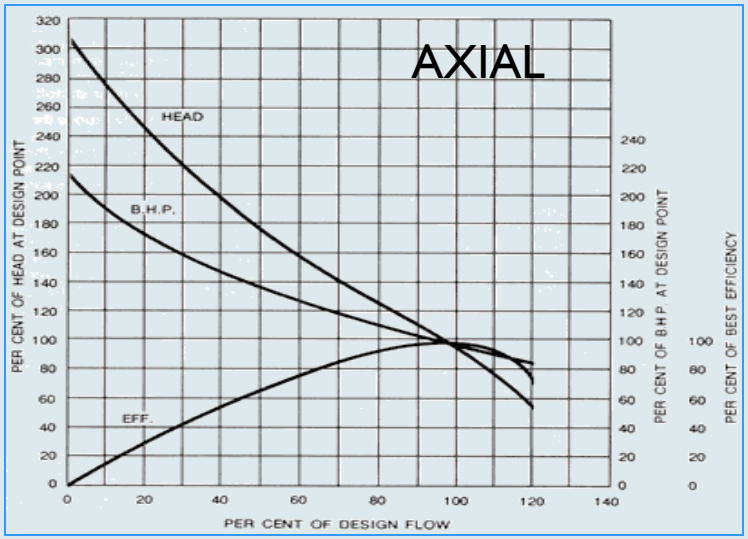


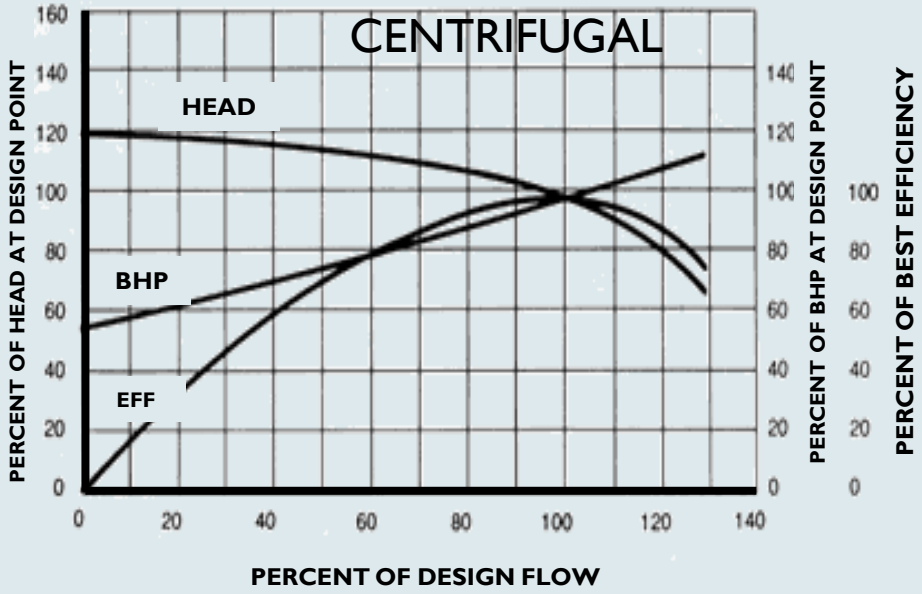
What is the risk of using a check valve on the delivery pipe in a pumping system?

Check valve is necessary to be located in the delivery part of the pump that to keep water in pipe and pump and as named it is non return valves. However it can cause damage to pump if this valve is not working properly .It can cause fluctuation in water pressure and may cause water hammer.

Why is it harmful to run an axial pump with the delivery valve closed?

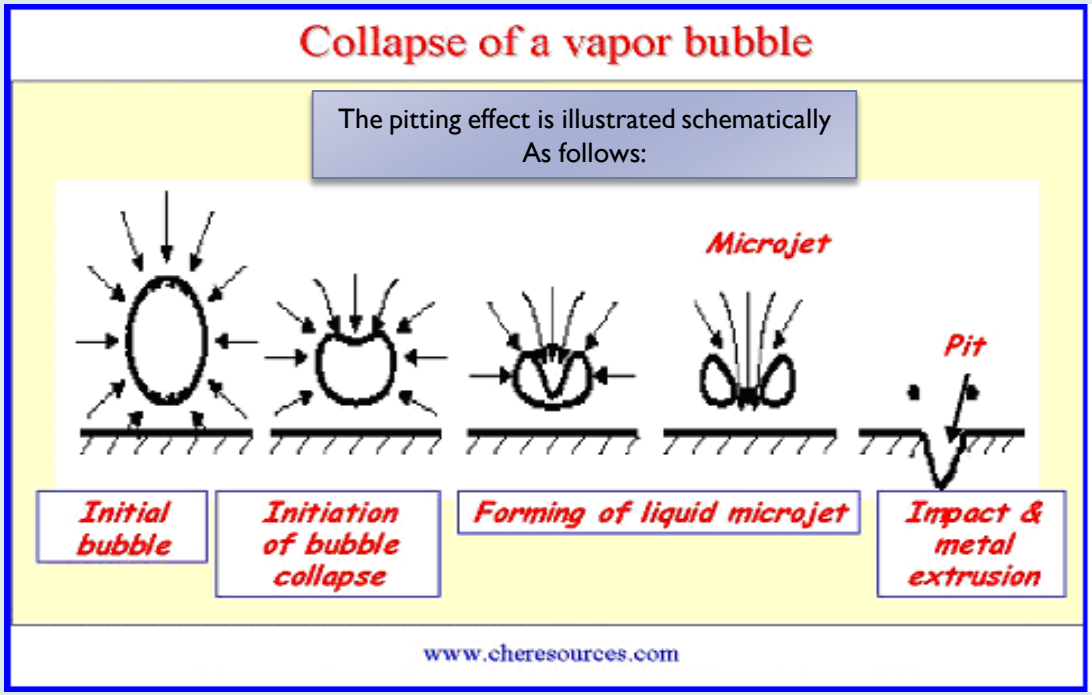
If you compare both performance curves (centrifugal & axial) you will see clearly that at no flow, axial pump has to work against very high Bhp power whereas centrifugal pump can operates at no flow for very short time since the Bhp is low.





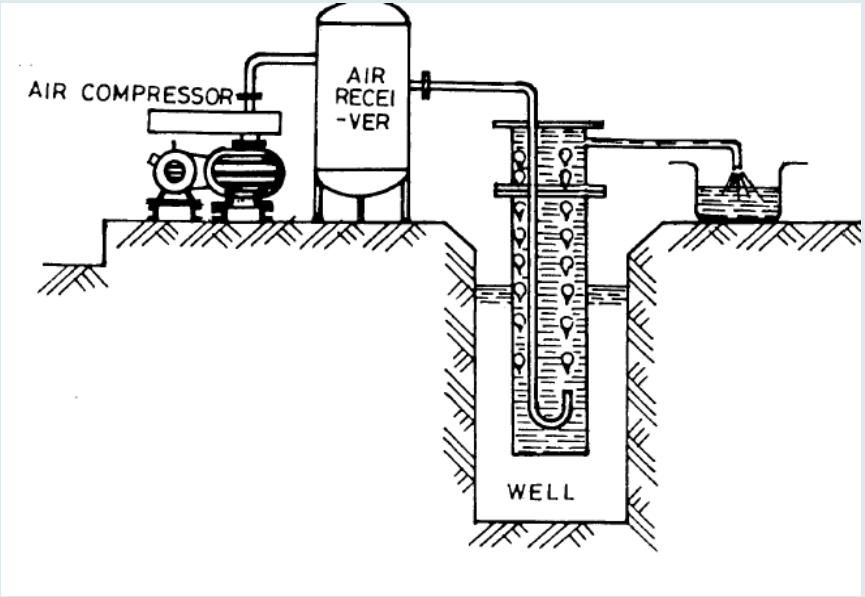
How can a vapor bubble damage pump impeller during cavitation?

The initial bubble of water vapor will collapse forming a micro jet that hits the pump's impeller. The repletion of this process at a very high rate will cause cavitation.

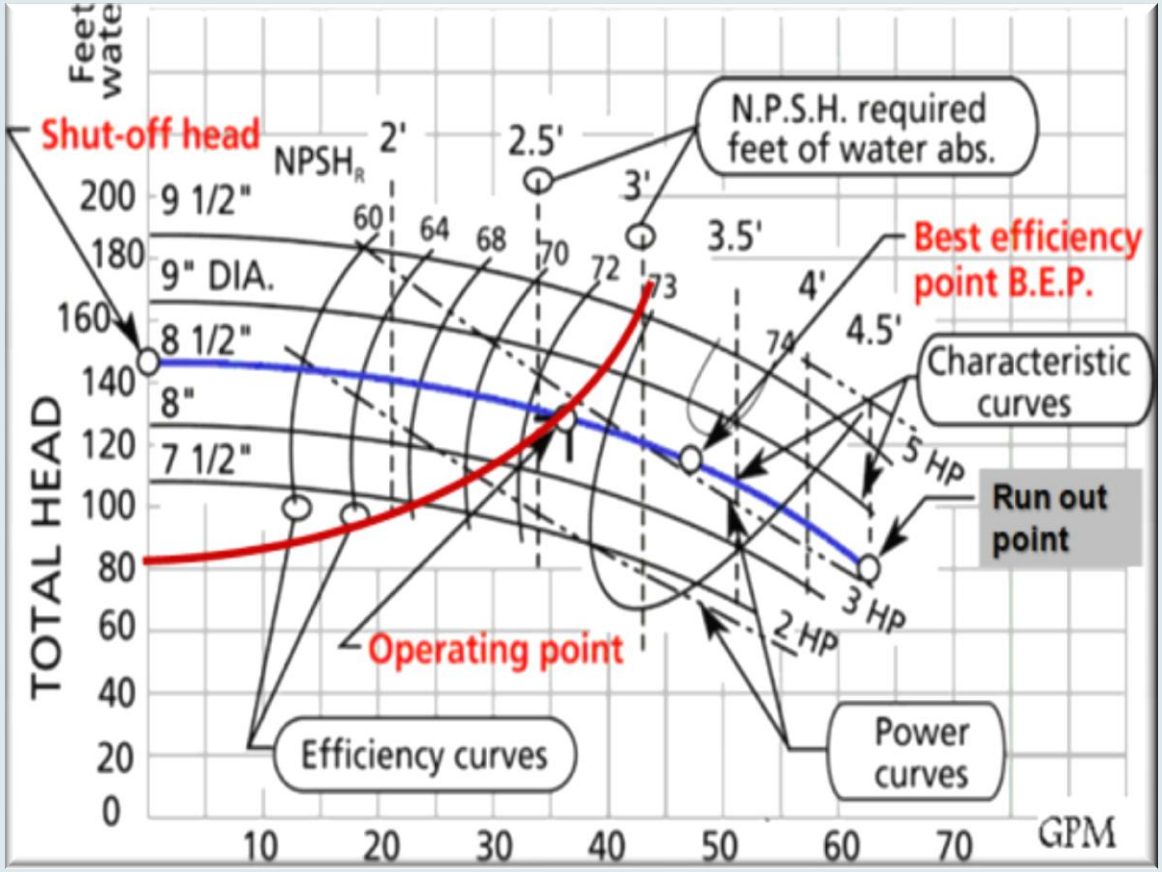


What is meant by air lift pump?

Figure below shows an example of air lift pump. It is none mechanical pump category since it has no mechanical movements or parts as in the case of rotary or PD pumps. It is used for lift water sand mixture or for dewatering . It requires air flow jet to lift water. It is low efficiency pump system.



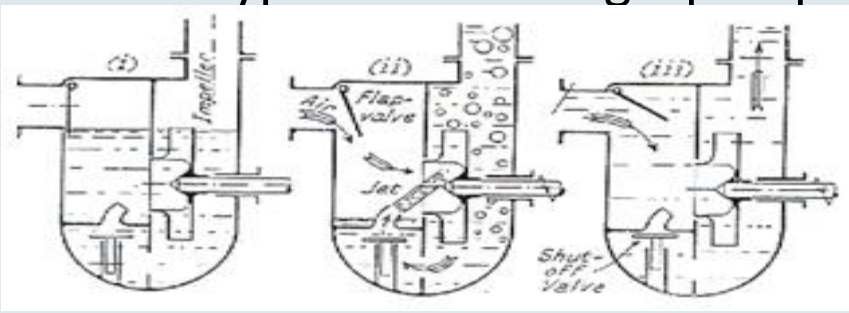
What is meant by Shut off head run out point and operating point?



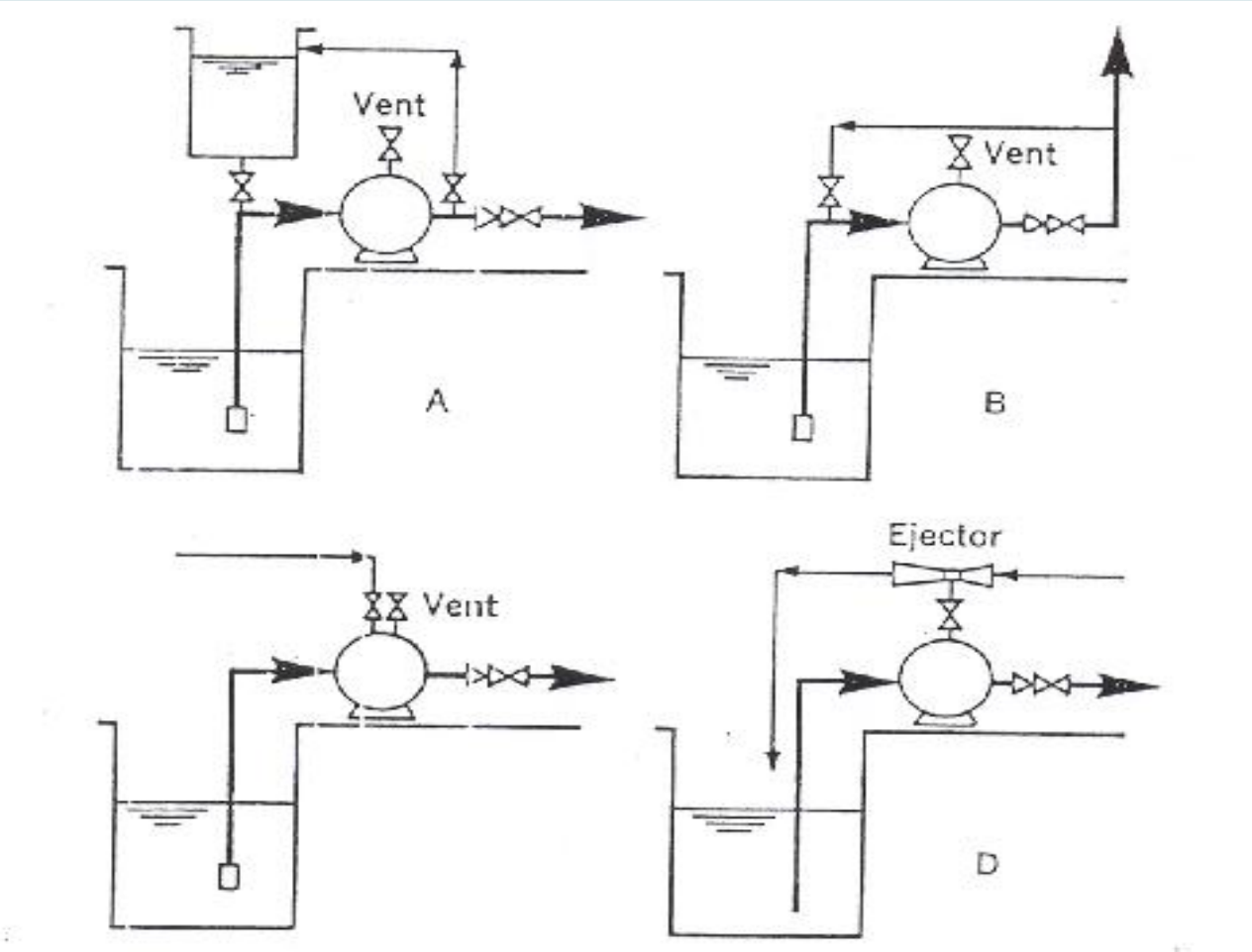
Why is it necessary to prime the centrifugal pump before operation? Describe the operation of self priming pumps.

To remove air . For that reason, centrifugal pumps must be filled with the liquid to be pumped before starting.

As described in figure below, this kind of pumps has the ability to evacuate air without any special external suction devices. They can handle water and air mixture. The pump is filled with water before starting it, and due to the presence of the non-return valve, the water will retain within the pump body after the pump is switched-off. Due to their specific construction, the efficiency of this kind of pump is low comparing with the other types of centrifugal pumps.

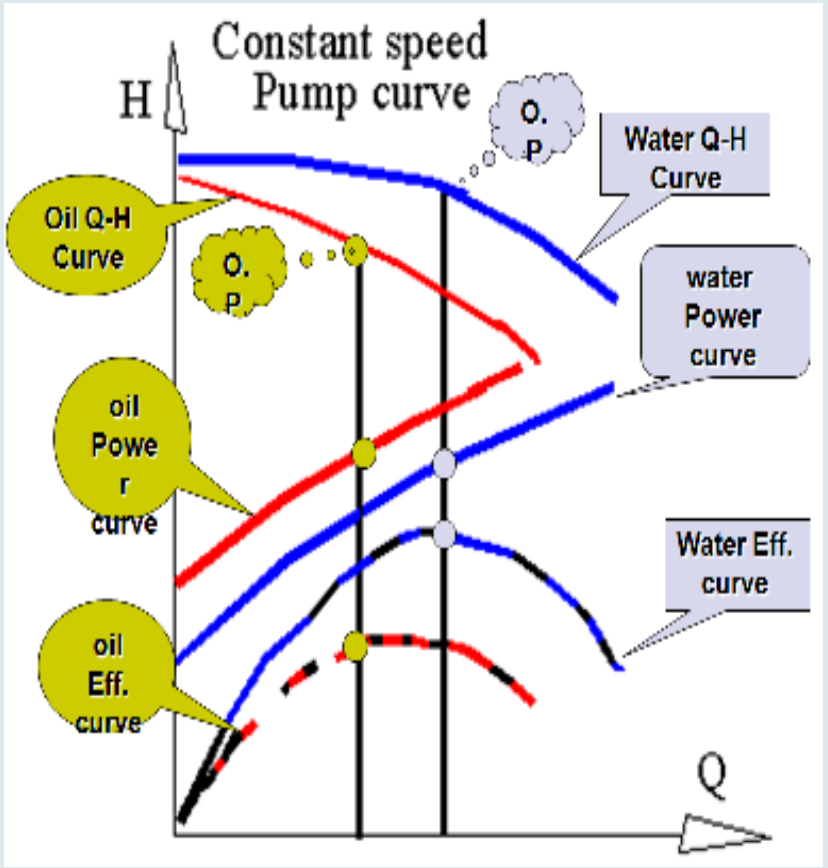


Describe with the help of neat sketch the function of self priming pump?



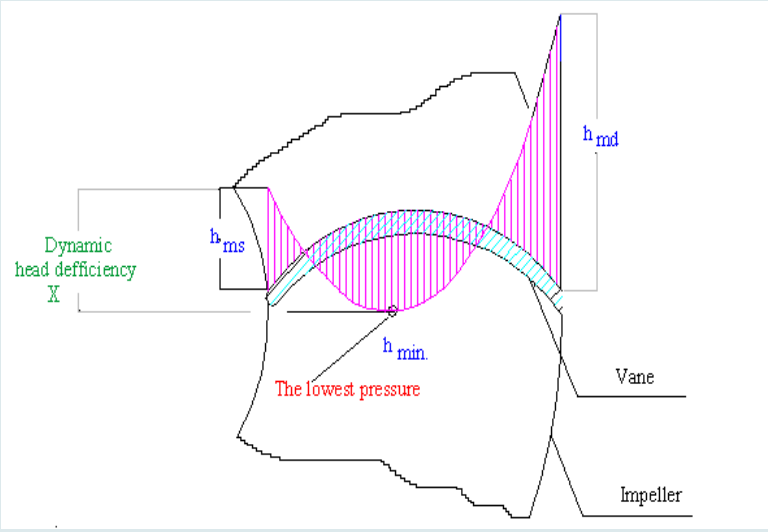
Discuss the effect of pumped liquid viscosity on the efficiency of a centrifugal pump.

- The brake horsepower requirement will increase.
- Reduction in the head the pump.
- Reduction in capacity will occur with moderate and high viscosities.
- Lowers the pump's efficiency.



What is meant by dynamic head deficiency?

The minimum pressure does not exactly occur at the inlet of the pump, but there is an additional pressure drop inside the pump due to the change in flow direction from axial to radial at very high rotational speed of the impeller. This action leads to an increase in eddy losses and sudden increase in flow velocity followed by reduction in pressure at the vane of the impeller as shown in figure below.

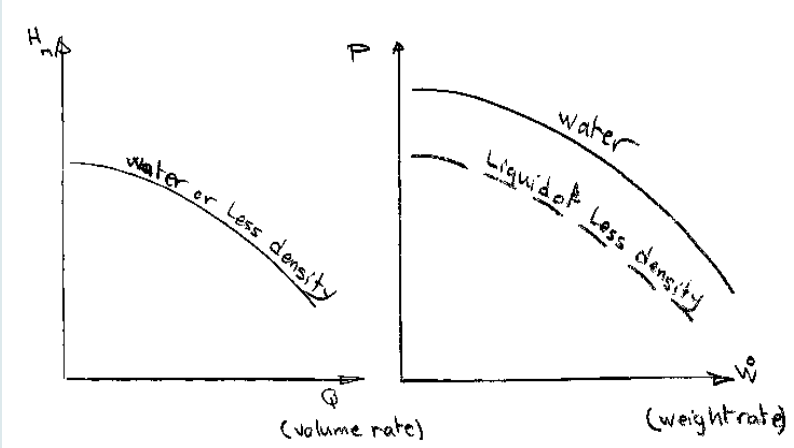


Why should not safety factor be used when calculating the head required by the pump?

Most engineers used safety factor in their calculation to avoid missing some uncounted fittings , aging effect etc.. (it is facto of dis-knowledge). However if high safety factor was used you may end up with large flow and head that means large pump and absorb power which is non-economical solution. Usually we used 5% for flow and 10% for head .

Effect of density or specific gravity on centrifugal pumps:

- No change in head of the pump, but the pressure will be proportional to the liquid Sp. Gravity
- No change in discharge but the weight rate will be proportional to S_g.
- No change in pump efficiency
- Power will changes and it is proportional to S_g.



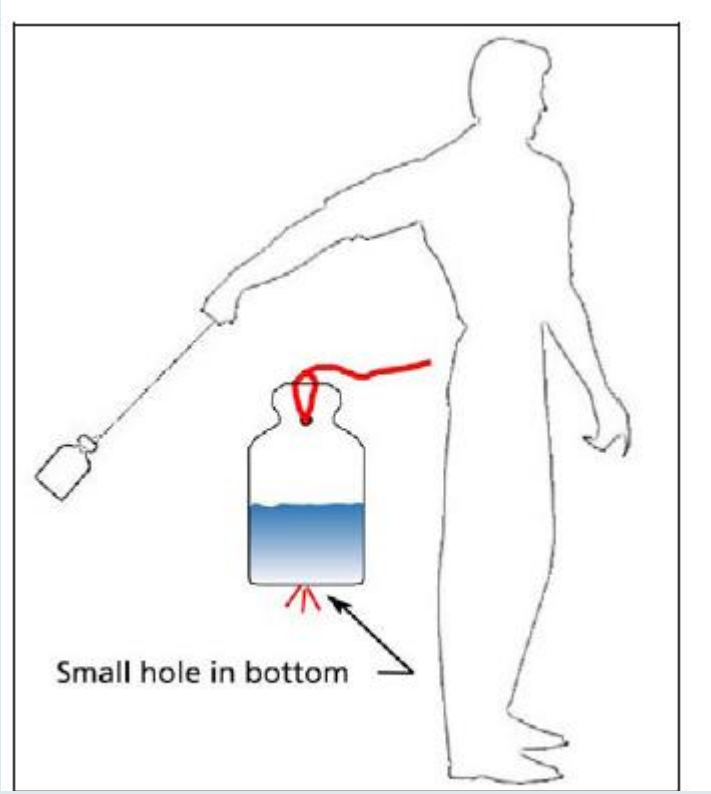
What does "Centrifugal " refer to in a centrifugal pump?

A centrifugal pump consist of an impeller rotating within a fixed casing or volute. Because the impeller blades are curved, the fluid is pushed in a tangential and radial direction. A force which acts in a radial direction is known as a centrifugal force. This force is the same one that keeps water inside a bucket which is rotating at the end of a string.

The rotation of the impeller causes the liquid contained in it to flow towards the periphery because of the centrifugal force generated. The center or eye of the impeller is thus evacuated and liquid from the suction line then flows in to fill the void inside the pump.

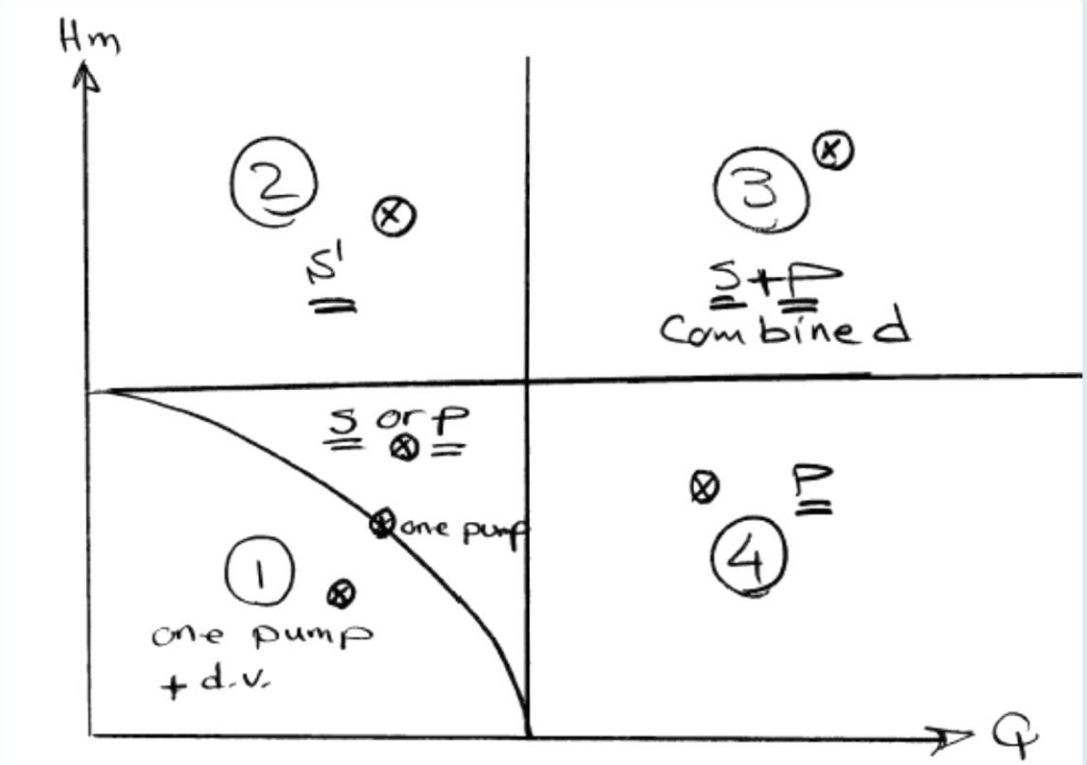
The job of a centrifugal pump is to generate enough pressure to overcome system hydraulic resistance. But it is the "responsibility" of the liquid to get to the pump. If the suction pressure is too low, the hydraulic losses can "eat away" enough pressure so that it could drop below the liquid vapor pressure.

What does "Centrifugal " refer to in a centrifugal pump?



Experiment with Centrifugal Force

What information is required to determine the number of identical pumps in a pumping system?



$n_p = \frac{Q_{req}}{Q_{p1}}$ $\quad Q_{p1} \rightarrow$ at H_{req}

$n_p = \frac{200}{90} = 2.- \longrightarrow 3$

$n_p = 3 +$ d.v. partially opened

↳ to reduce Q to Q_{req} (250) (200)

$Q_p = \frac{Q_{req}}{n_p} = \frac{200}{3}$

$H_p = H_t$

$P_{sh_t} = n_p \cdot P_{sh_p} = n_p \cdot \frac{\omega Q_p H_p}{c \eta_p}$

$P_{sh_{L.V}} = \frac{\omega Q_{req} h_{L.V.}}{c \eta_o}$

In which situation could we use two pumps in parallel with different rating?

It is not recommended to use two non identical pump in series or parallel. But it happens that you have a large pump and you decide to add another one to increase the flow and it was difficult to find the same manufacturer of your old pump .In this case we may use two non identical pumps.

How is the number of stages of a multistage pump calculated?

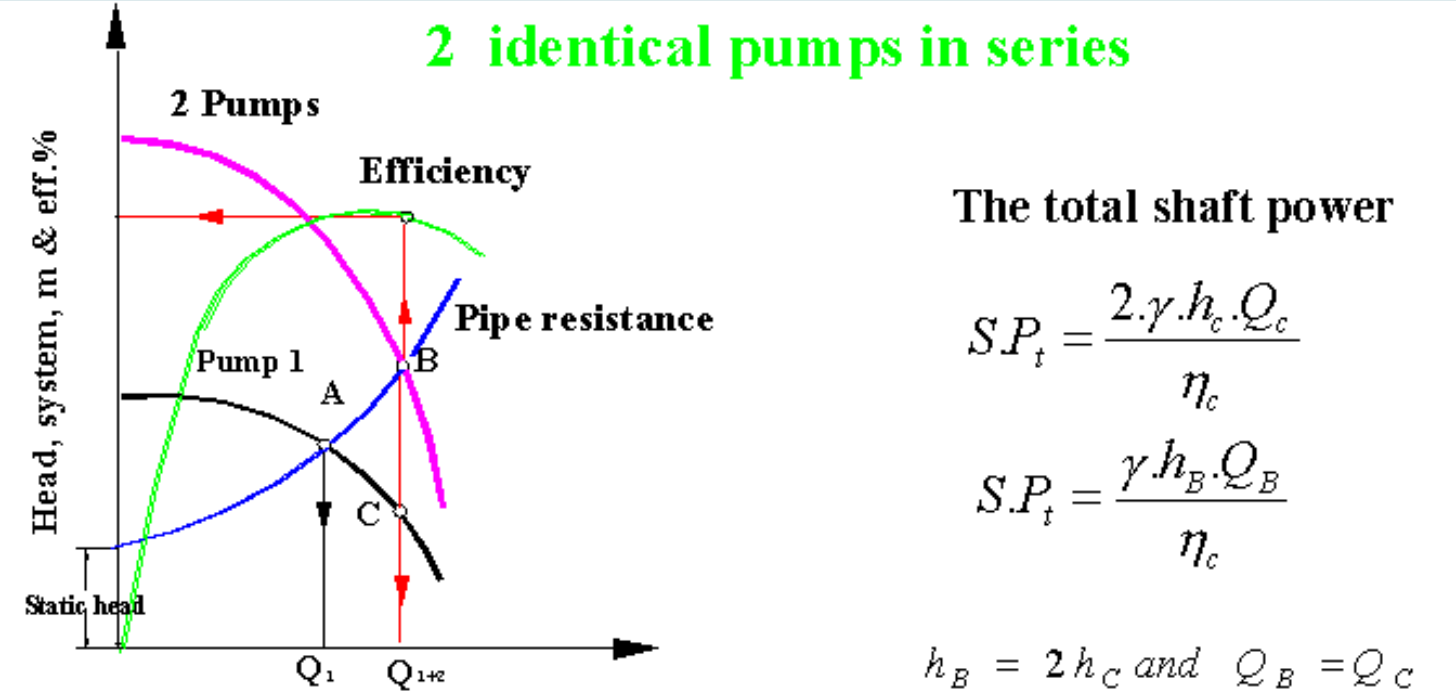
Similar to pump in series.

Multi-stage turbine pump

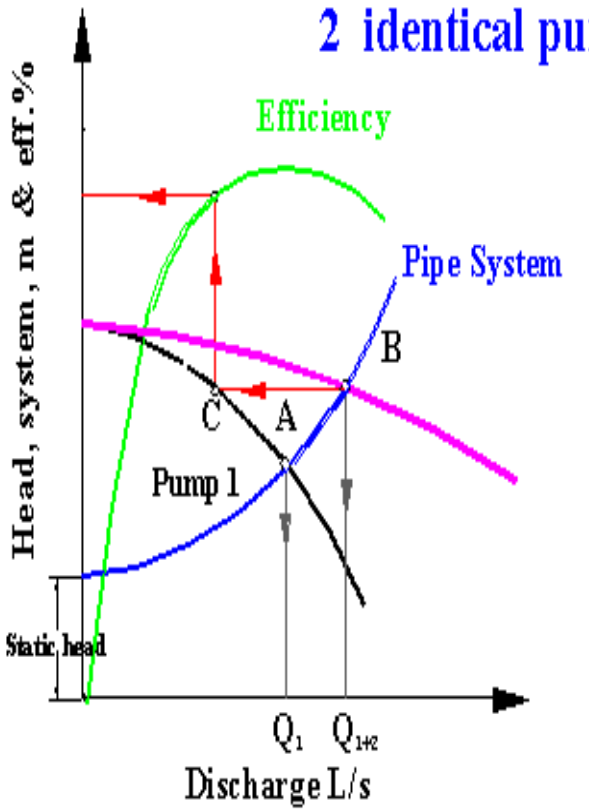
$Q_1 = Q_2$ & $TDH_{tot} = TDH_1 + TDH_2$ (add heads at the same discharge)

Number of stages = TDH/TDH of a single stage

How can you determine the shaft power of a system having two identical pumps in Series?



How can you determine the shaft power of a system having two identical pumps in parallel?



The total shaft power

$$S.P_t = \frac{2.\gamma.h_c.Q_c}{\eta_c}$$

$$S.P_t = \frac{\gamma.h_B.Q_B}{\eta_c}$$

$h_B = h_C$ and $Q_B = 2.Q_C$