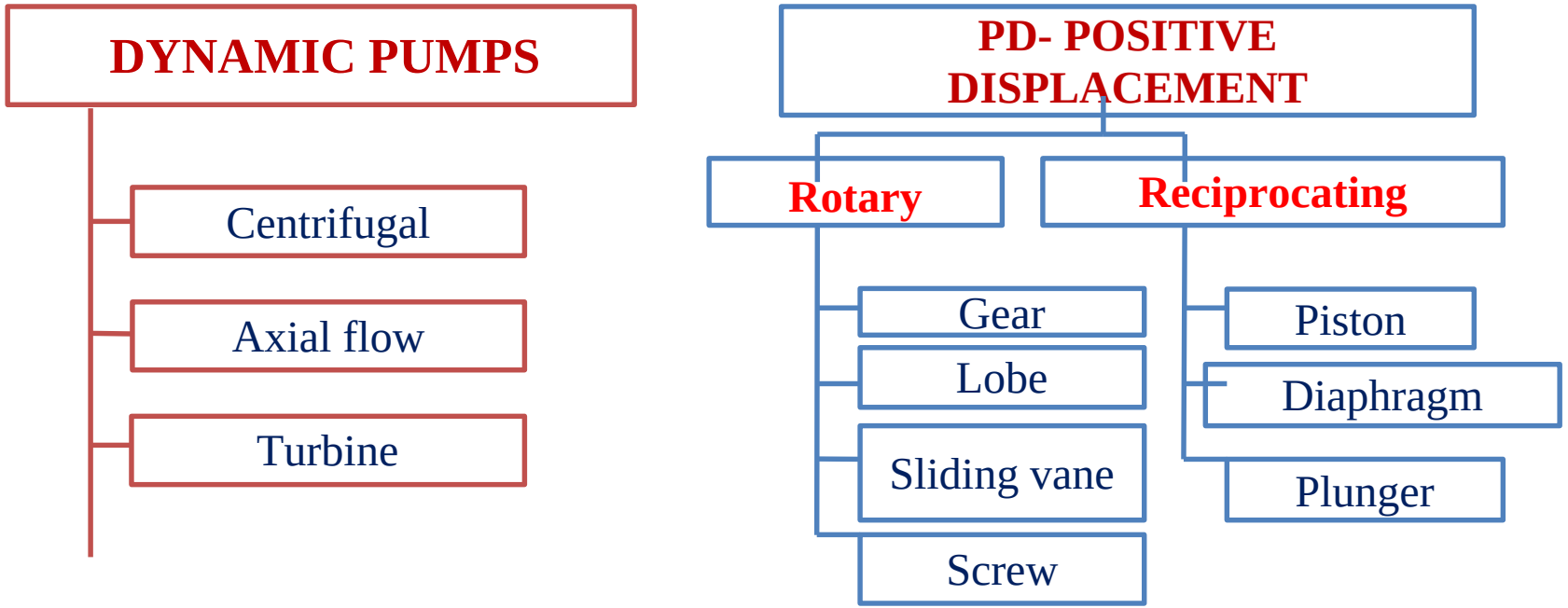
CENTRIFUGAL PUMP

CENTRIFUGAL PUMP CONTENTS

PUMP

Pump is a machine that adds energy to the liquids.

PUMPS



PUMP

Why pumps are required?

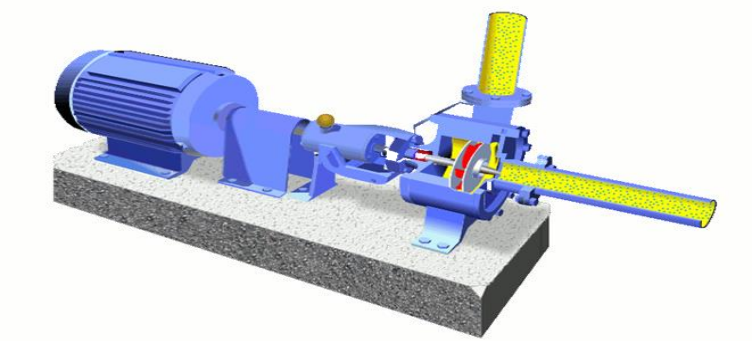
- To increase pressure of liquids.
- To increase flow of liquids.
- To move liquid from one point to another at same or higher elevation.

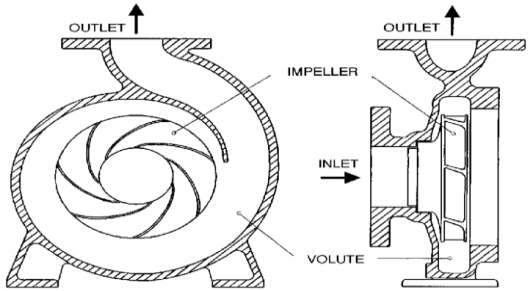
Pumps can be broadly divided into TWO main categories:

1) KINETIC PUMPS (DYNAMIC PUMP)
2) POSITIVE DISPLACEMENT PUMPS (PD-PUMP)

CENTRIFUGAL PUMP

- A pump that works on the basis of centrifugal force is called centrifugal pump.
- A centrifugal pump operates by increasing the velocity, or speed of a liquid.
- Centrifugal pumps are generally used where high flow rates and moderate head increases are required

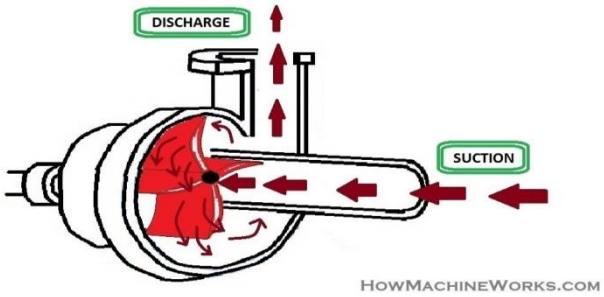


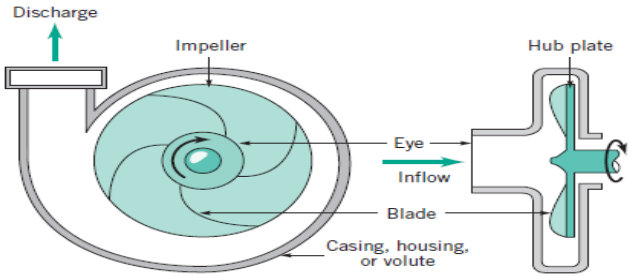


CENTRIFUGAL PUMP

Working principle

- Fluid enters the eye of impeller
- Impeller adds energy (velocity) to the fluid.
- Volute casing converts velocity to pressure.

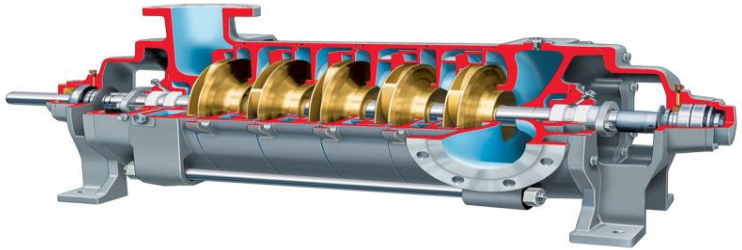


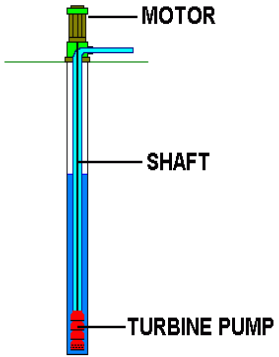


CENTRIFUGAL PUMP

Types of Centrifugal Pump

- Single Stage Centrifugal Pump.(Double suction single stage pump)
- Multi Stage Centrifugal Pump.
- Propeller Pump
- Turbine Pump.



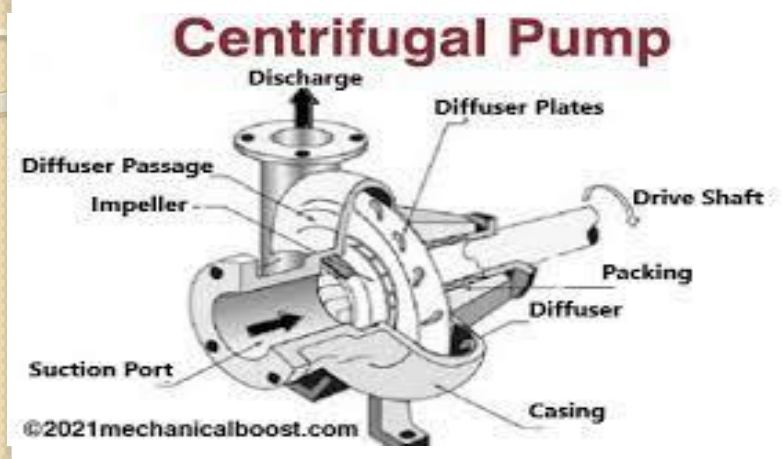


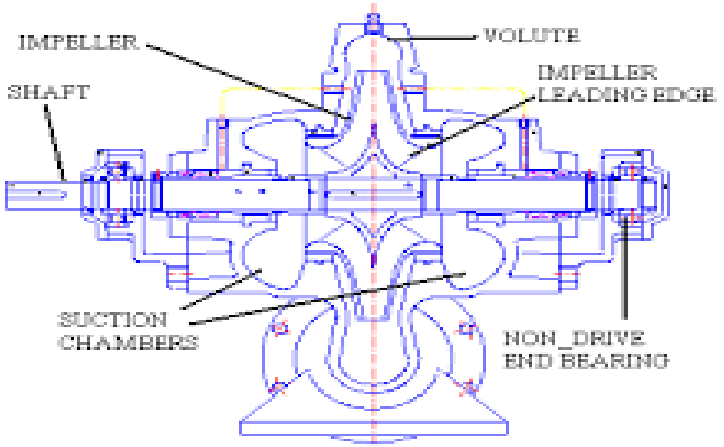
CENTRIFUGAL PUMP

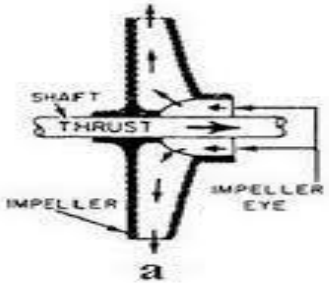
Single Stage Centrifugal Pump

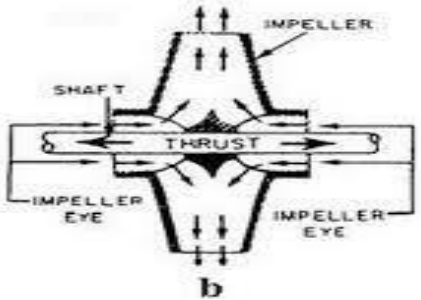
- Only one impeller on the shaft.
- Used for low/medium pressure application.
- Available in both horizontal & vertical arrangements.
- Mostly end suction with overhung impellers.
- Impellers may be single suction or double suction.

Single Stage Centrifugal Pump



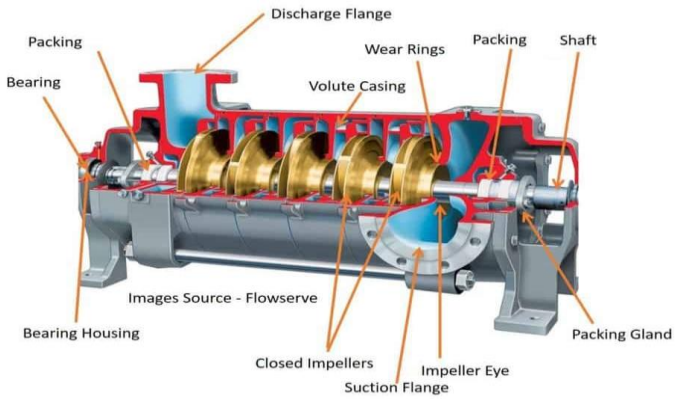


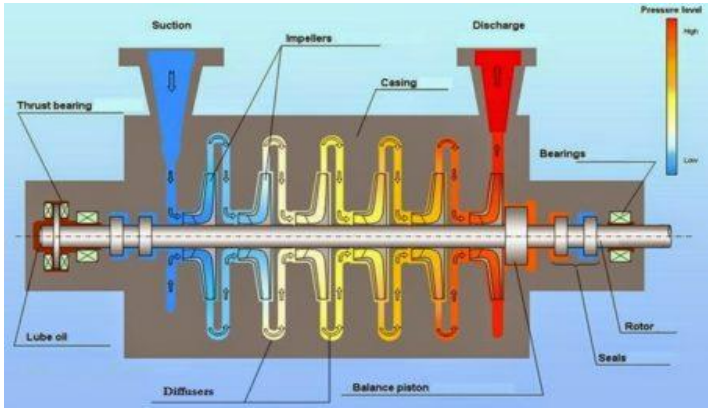




Multi-Stage Centrifugal Pump

- Having two or more impellers on a shaft in series.
- Used for higher discharge head.
- Impellers are located at the center of shaft.
- Rotor is supported at shaft ends.
- It has two stuffing boxes.

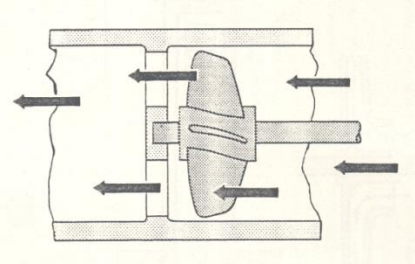


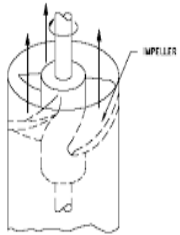


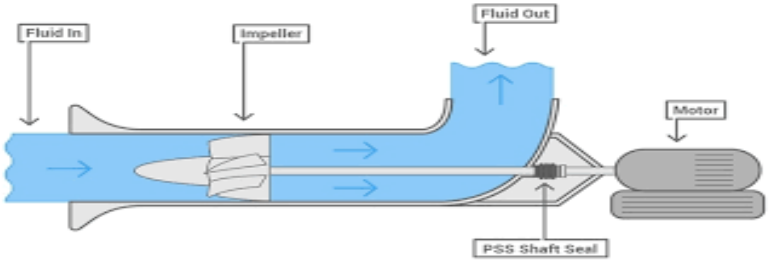
Multi-Stage Centrifugal Pump

Propeller Pump

- Axial flow pumps, also called propeller pumps, are centrifugal pumps which move fluid axially through an impeller.
- Provide high flow rate
- Low head (Low head and discharge pressures)
- Liquid leaves the propeller in the same direction as it enters.

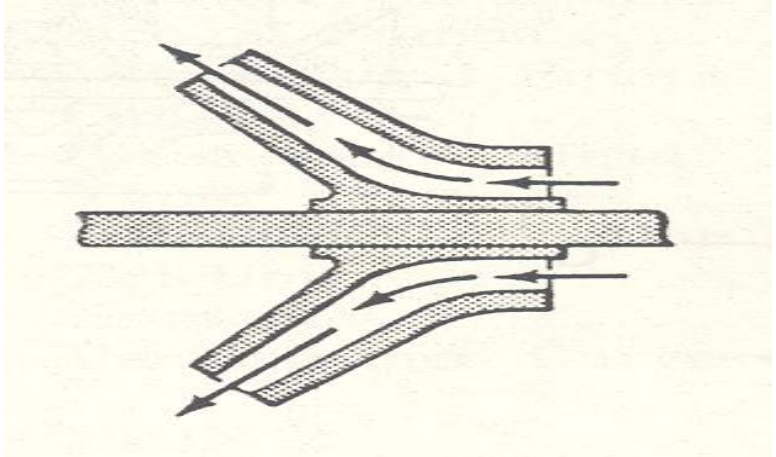






Turbine Pump

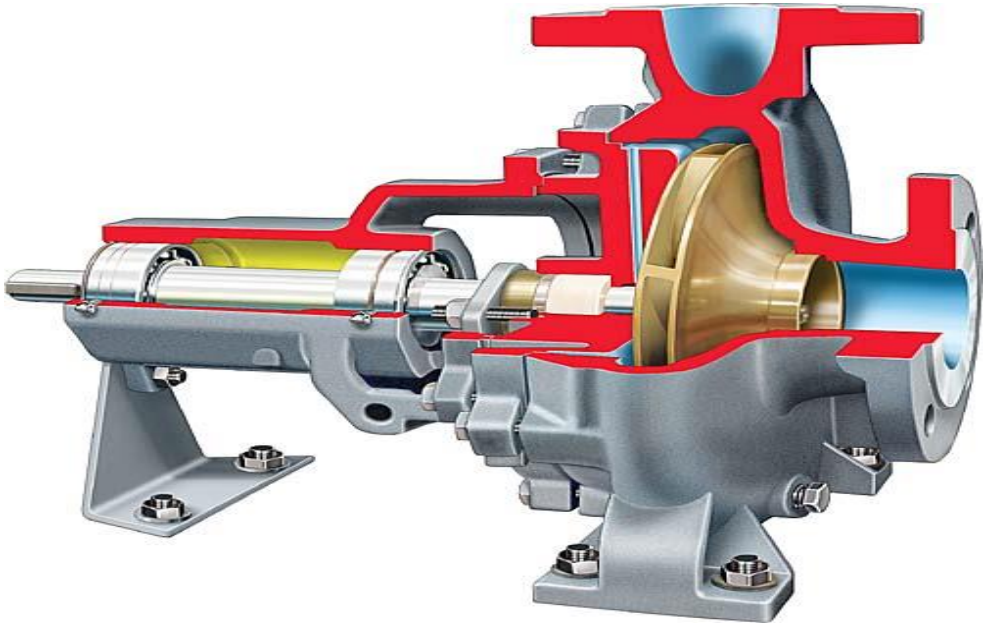
- A vertical turbine pump commonly removes water from an underground well or reservoir.
- Mixture of impeller & propeller pumps.
- Turbine pump can be single or multistage.
- Generates high head and high discharge pressure.
- Low flow rate



Parts of Centrifugal Pump

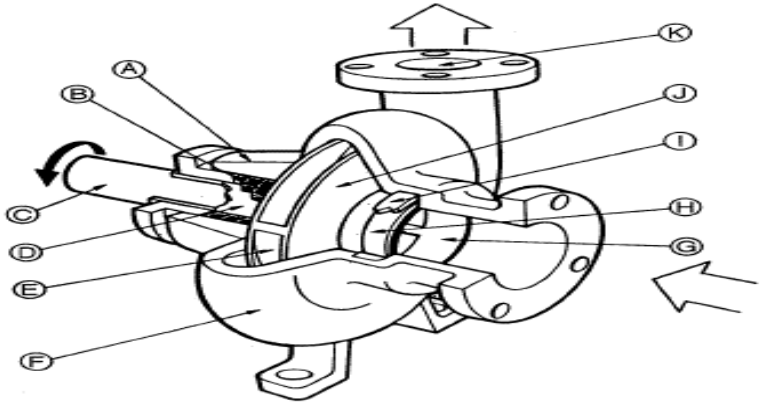
The main parts of a centrifugal pump are:

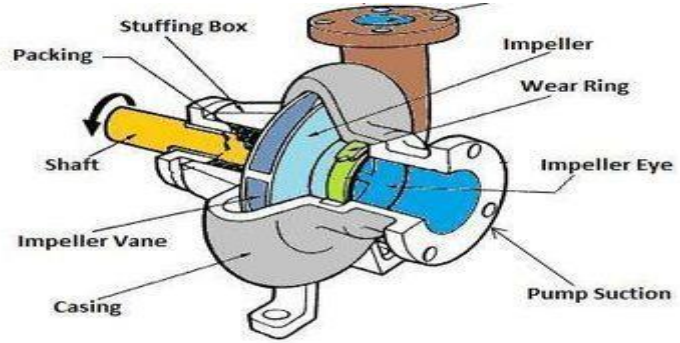
- Impeller
- Casing
- Diffuser
- Stuffing Box
- Seals/Packing
- Bearings



Parts of Centrifugal Pump

A. Stuffing Box
B. Packing
C. Shaft
D. Shaft Sleeve
E. Vane
F. Casing
G. Eye of Impeller
H. Impeller wear ring
I. Casing Wear Ring
J. Impeller
K. Discharge Nozzle





Impeller

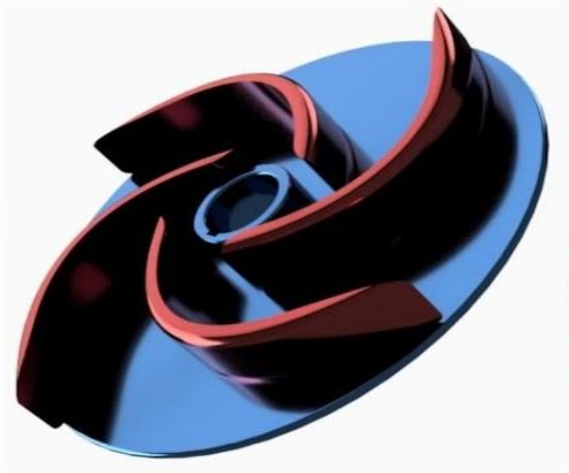
- Most important part of centrifugal pump.
- Mounted on shaft & rotates with it.
- ✓ Reducing running clearance results in increased efficiency of the pump and reduce metal to metal contact.

Commonly used materials for impellers include:

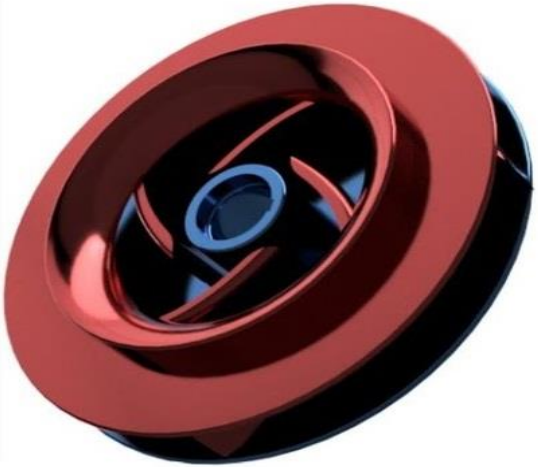
1. cast iron
2. cast steel
3. stainless steel
4. alloy steel
5. carbon steel
6. Non-metallic materials.

Impellers

Open impeller



Semi-open impeller



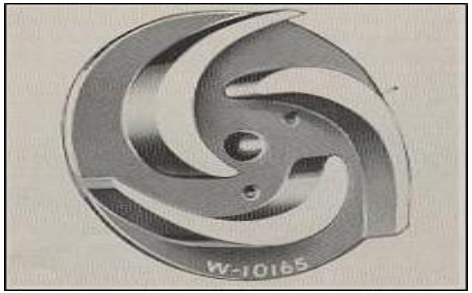
Closed impeller

Types of Impeller

Open Impeller

- Vanes are attached to the hub.
- No shroud to support vanes.
- Applied in pumps handling slurries & mud
- Good for pumping stringy materials such as paper stock.

Semi Open Impeller

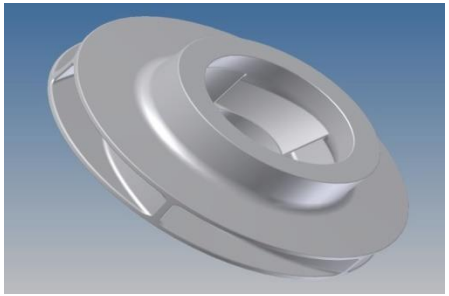


- Vanes are attached to the hub.
- Shroud on one side of the impellers.
- Applied in pumps handling abrasive liquids
- Good for viscous fluids.

Types of Impeller

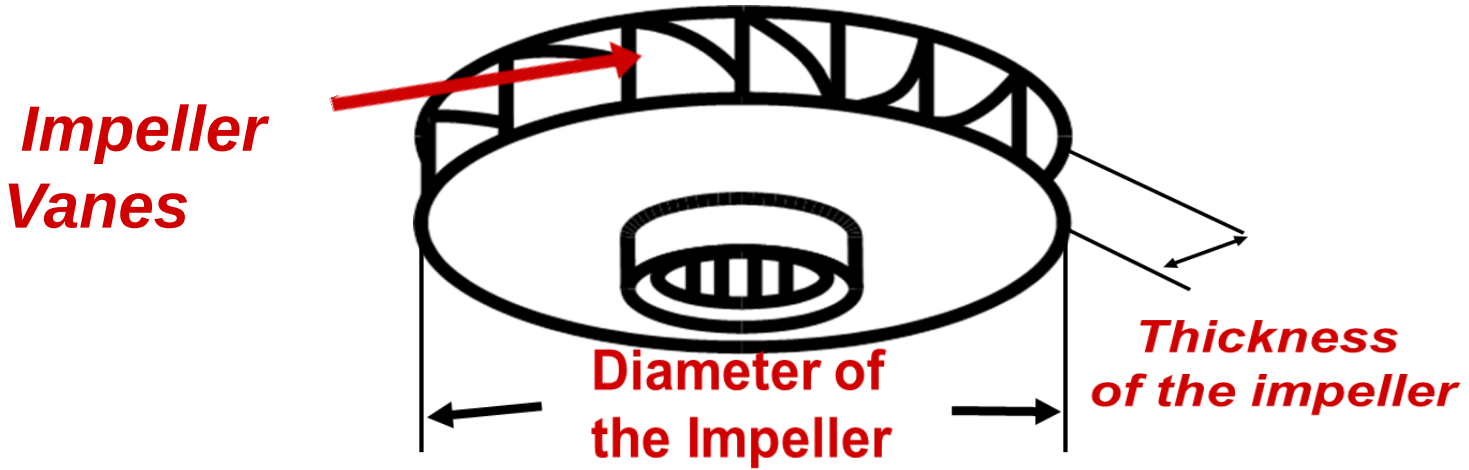
Closed Impeller

- Vanes are attached to the hub.
- Shrouds on either sides of the impeller.
- Pump efficiency is maintained by the use of close clearance wear rings.
- Applied in pumps handling clear liquids



Close impeller

- Thicker the Impeller - More Water
- Larger the DIAMETER - More Pressure
- Increase the Speed - More Water and pressure



Wear Rings

- Maximize efficiency by reducing the leaking.
- Minimize the cost of pump maintenance.
- Replaceable periodically during the pump life.
- ✓ Improve pump performance approx. (3–5 %) and also increase the life of pumps and impellers.

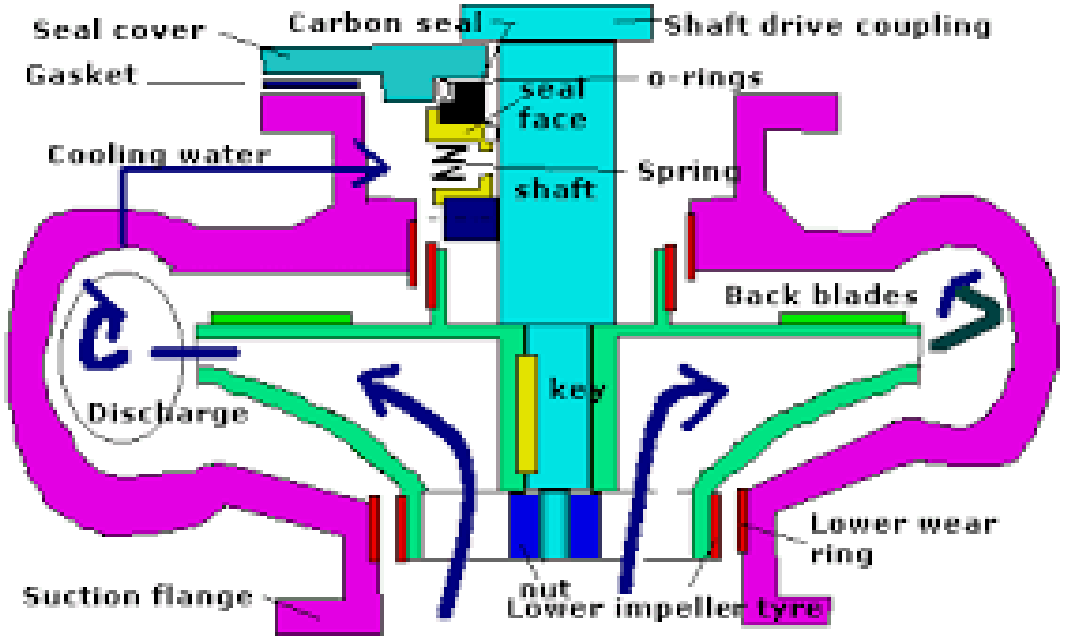
1) Impeller W/ring to hub (0.05 mm to 0.08 mm) interference.
2) Casing w/ring to casing: (0.05 mm to 0.08 mm) interference.
3) Impeller W/ring to casing w/ring clearance

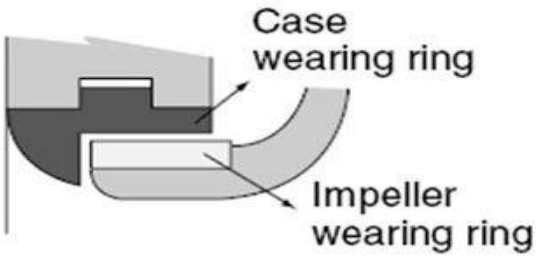
(0.25 mm to 0.30 mm) plus (0.03 mm)

Throat bushing Throat bushing to case (0.05 mm to 0.08 mm) interference.

Throat bush to shaft (0.40 mm to 0.51mm) clearance.

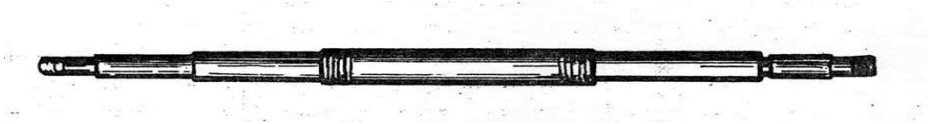
Wear Rings


Seal cover
Carbon seal
Shaft drive coupling
Gasket
o-rings
seal face
Cooling water
Spring
shaft
Back blades
key
Discharge
Lower wear ring
Suction flange
nut
Lower impeller
Lyre


Case wearing ring
Impeller wearing ring

SHAFT

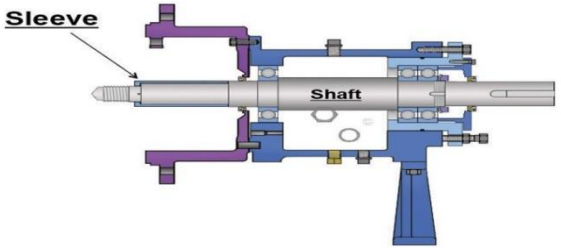
- The main function of the shaft in a centrifugal pump is to transmit the input power from the driver into the impeller.
- Shaft runout=0.05 mm



SHAFT SLEEVE

- The basic function of the sleeve is to protect shaft from erosion, corrosion and wear at stuffing boxes, leakage joints & internal bearing areas.
- Sleeve to shaft (0.03 mm to 0.04 mm) clearance.

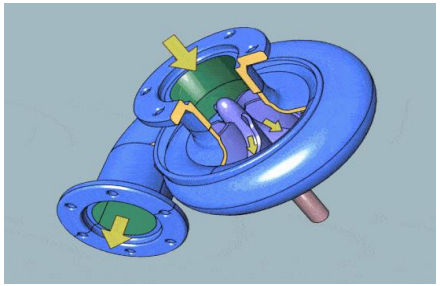
Shaft Sleeve



Pump Casing

- Enclosed space where the impeller rotates with the shaft.
- Converts velocity of liquid into pressure.
- Has close clearance with the impeller.
- Has two ends, Suction & Discharge.
- Stuffing box is also provided in it.
- The most common materials used in the pump casing include:

cast iron, stainless steel and carbon steel.



Types of Casing

1-Volute Casing

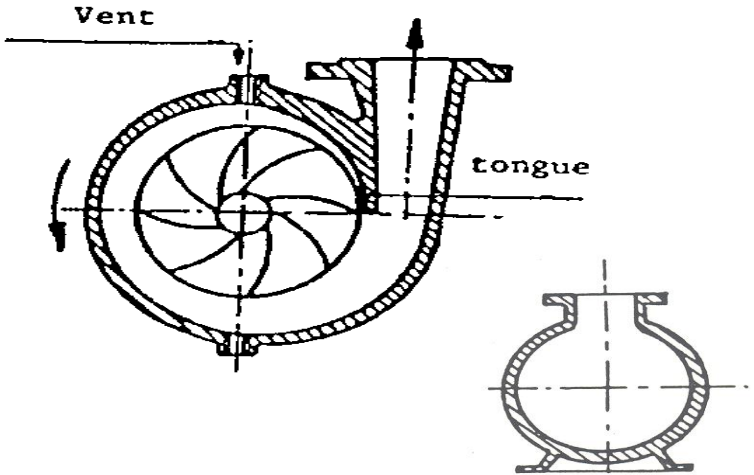
- Passage increases towards discharge nozzle.
- Pressure increases due to increase in area of the volute.

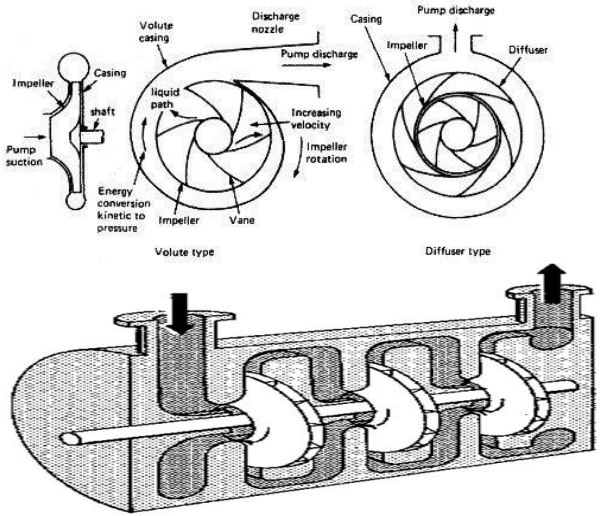
2-Concentric Casing

- Discharge nozzle is always on vertical plane along the center line of pump.
- A diffuser is a set of stationary vanes that surround the impeller.
- Diffuser is used to convert velocity into pressure.

Types of Casing (Diffuser)

- It is the stationary component in the pump casing.
- It converts velocity into pressure.
- It also guides the liquid towards discharge nozzle.
- In multistage pump, diffusers guides liquid to the eye of next stage impeller.





Stuffing Box

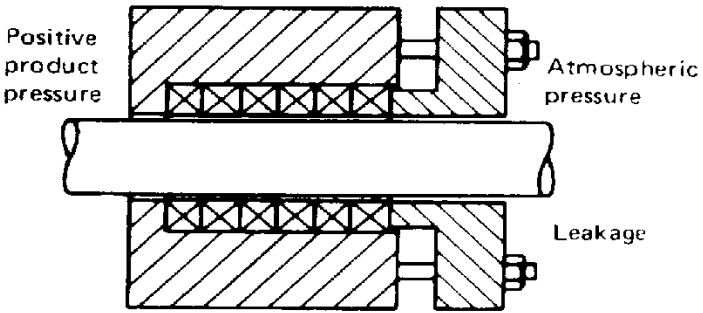
- The Stuffing Box is a cylindrical space in the pump casing surrounding the shaft.(Packing Box)
- Filled with a flexible, low friction and non-abrasive material. Shaft part is protected by a removable sleeve.

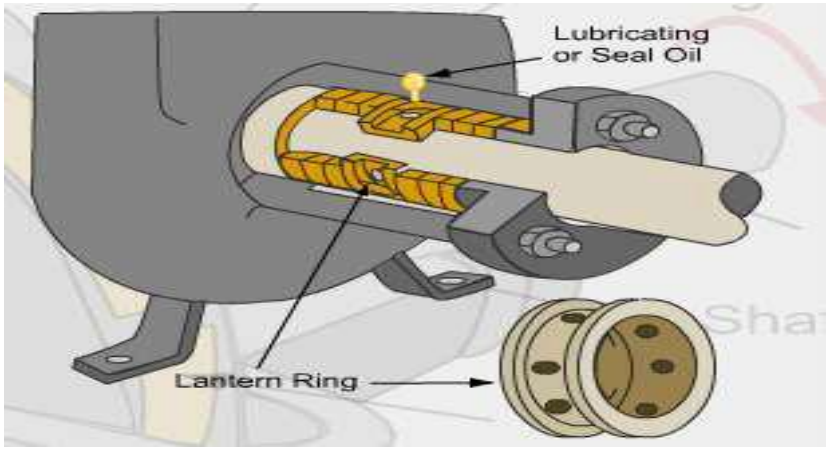
Lantern Rings

- The lantern ring is used to distribute cooling water to all packing rings as well as keep the stuffing box clean of containments.

PACKING

- Packing is used to reduce wear between stationary and moving pump parts.
- To reduce water, packing must be made of low friction material.
- Packing is chosen for the nature and temperature of the pumping liquid.





Bearing Types

Bearing

- Bearings are designed to minimize friction, wear and power losses.

Main types

1) Plain bearings

2) Anti-friction bearings

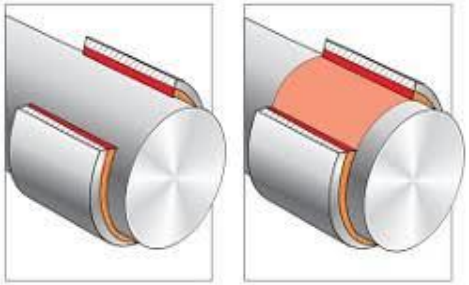
Bearings can also be classified on the basis of function:

1) Journal Bearing – For Radial Loads.

2) Thrust Bearing – For Axial Loads.

3) Guide Bearing – For Vertical Pumps

Bearing Types



Oiler

- The device is installed on the equipment and oil is filled to the level glass.
- All constant level oilers require air to function properly.
- Oil level within the sump lowers, the seal at the control point is broken, allowing air to enter the reservoir and displace the oil until the seal is reestablished.

Oiler

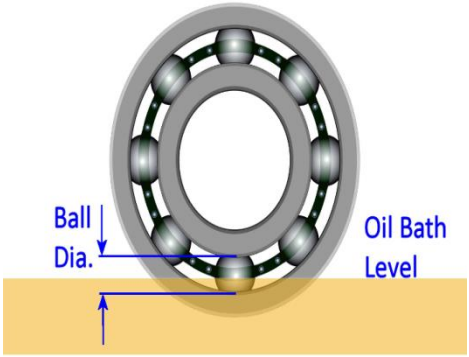
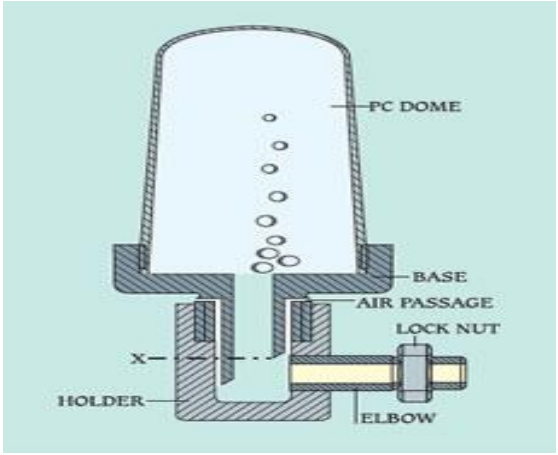
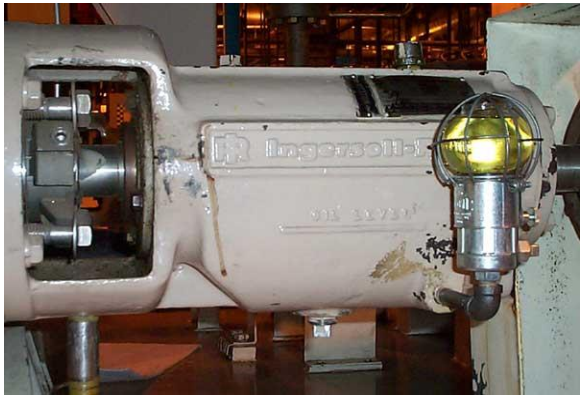
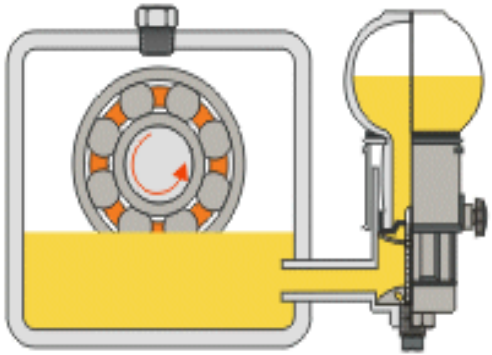
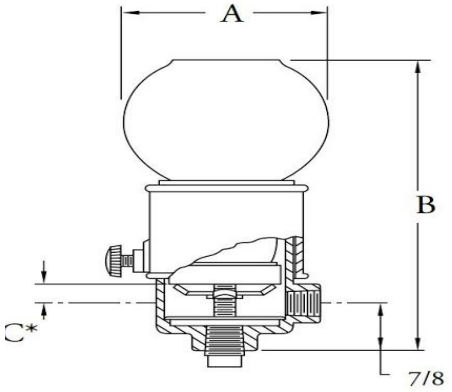


Figure 1: Oil bath lubrication showing a typical oil level







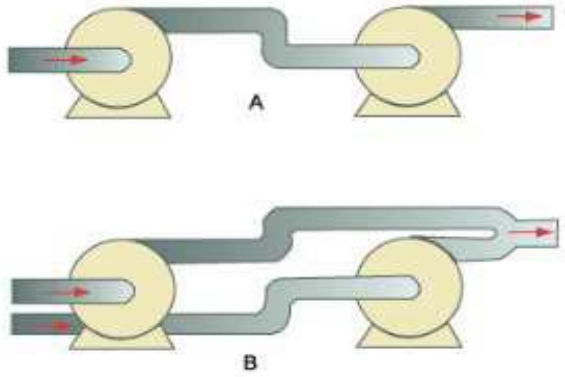


Series and Parallel operation

A. When the discharge of one pump is fed into the suction of another pump, the two pumps operate in series. This **increases the discharge head** of the system.

B. Pumps that discharge into the same line are operating in parallel.

C. Operating pumps in parallel **increases the capacity**.



Axial Balancing

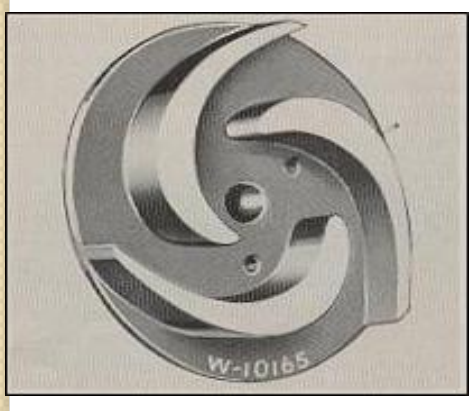
- When a pump is in operation axial forces are also exerted on the impeller.
- The open impeller with no shrouds has very low axial thrust loading because there are no shrouds for the differential pressure to build up.
- Semi-open impellers actually have one shroud that allows the discharge pressure to build up.
- Closed impellers with two shrouds make it much easier to balance.

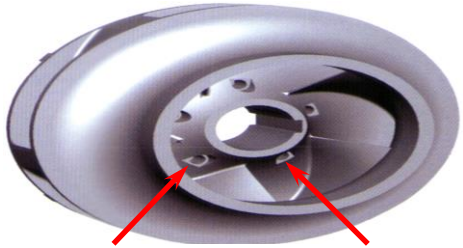
1. Balancing holes
2. Ribs on the back of the impeller (back vanes)
3. Double inlet flow from both sides of impeller
4. Hydraulic Balancing

Axial Balancing

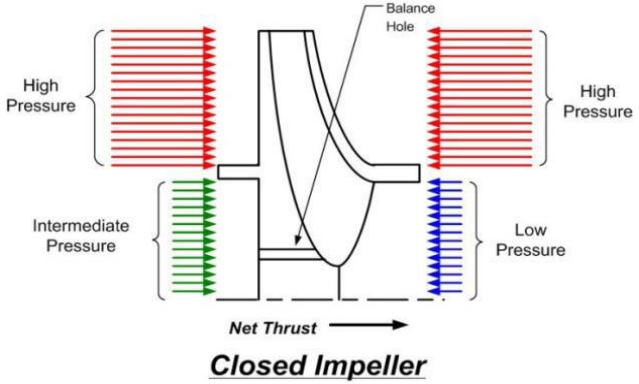
Balancing Holes

- One of the most popular forms of thrust balancing device is to drill balance holes through the rear shroud of the impeller allowing the high pressure at the back of the impeller to bleed through the balance holes back into the suction





BALANCING HOLES

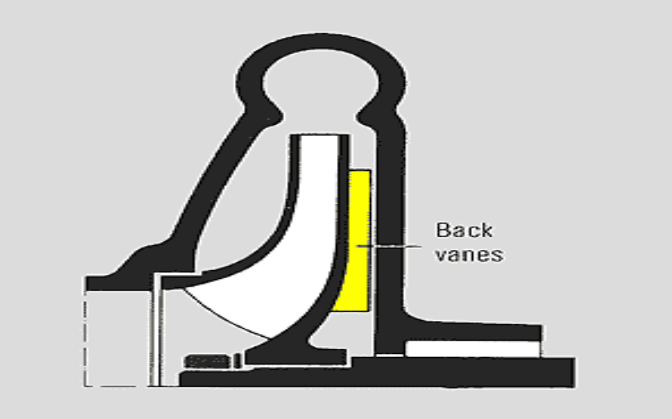


Closed Impeller

Axial Balancing

Back Vanes

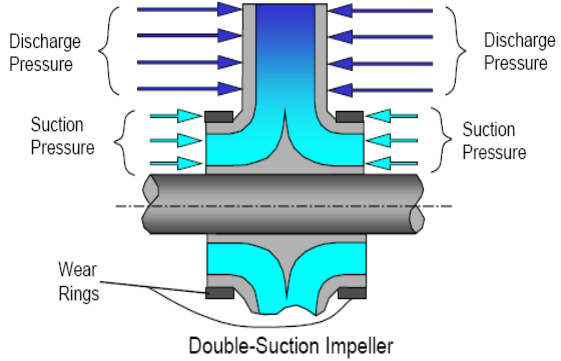
- The back vane is a radial narrow vane on the rear shroud (viewed in flow direction) of a radial impeller or mixed flow impeller designed to balance the axial thrust.

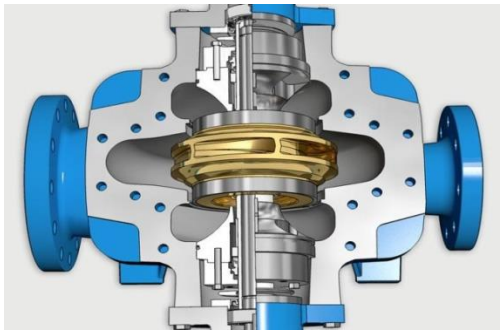


Axial Balancing

Double suction impellers

- A special pump design is required for double suction impeller.
- The axial forces that act on the impeller completely neutralize each other as the liquid enter the impeller from both sides.

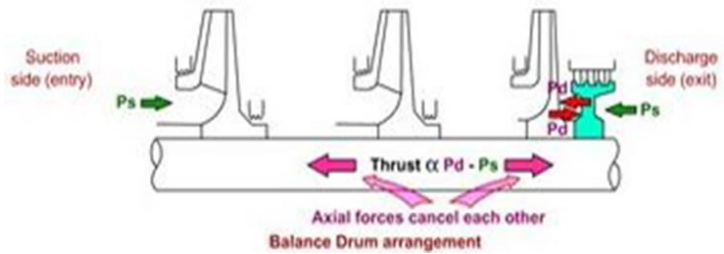




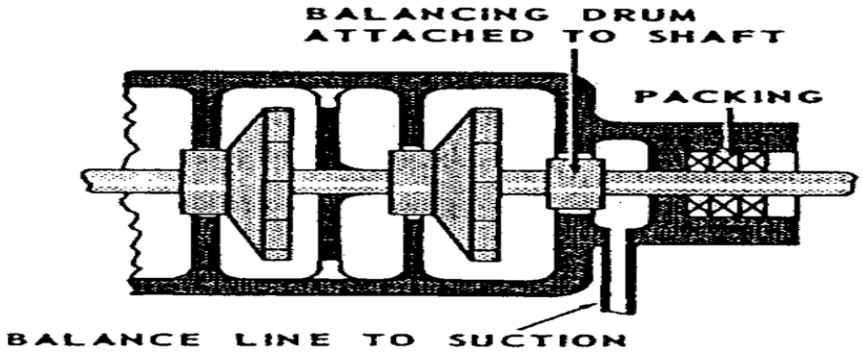
Axial Balancing

Hydraulic Balancing (BALANCING DRUM)

- This method is used in multi stage pumps.
- A balancing drum is mounted on the shaft behind the last impeller, which rotates with a small radial clearance.
- Balance line is used to balance the centrifugal pump shaft from axial thrust

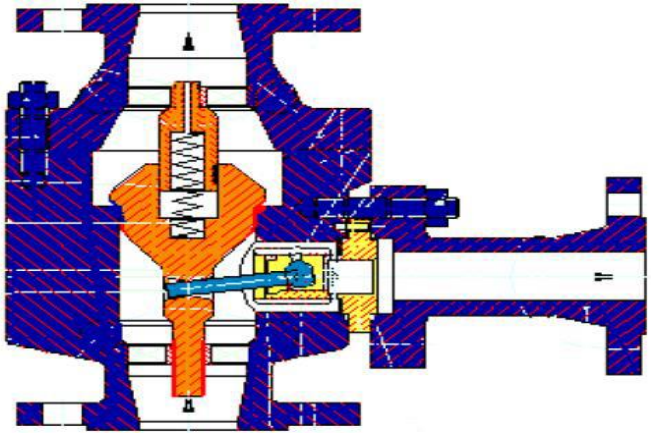


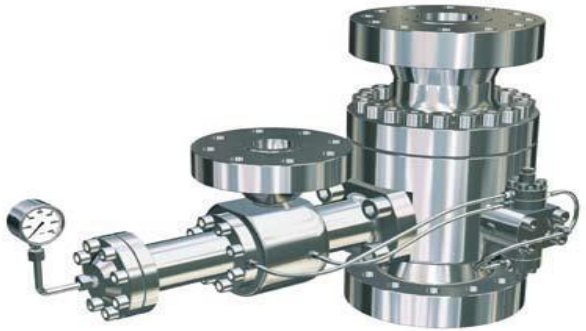
Balance Drum arrangement



Minimum Flow device (MFD)

- A centrifugal pump can overheat and be damaged when flows are less than the minimum amount specified by the manufacture.
- Minimum flow device MFD installed in discharge piping of the pump.
- The primary function of Minimum flow device (MFD) is to maintain a minimum flow thru the pump at low loads





What is Net Positive Suction Head?

Pump Head

- Head is the height of liquid.
- NPSH stands for Net Positive Suction Head
- NPSH is the difference between suction pressure and vapor pressure. In equation form: NPSH = Ps - Vapor pressure
- Absolute pressure = gauge pressure + atmospheric pressure. NPSH is normally considered in two forms: NPSH-R (NPSH Required) and NPSH-A (NPSH Available).

NPSH Available (NPSHA)

The absolute pressure at the suction port of the pump.

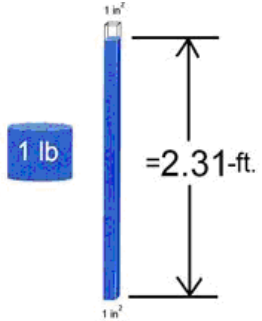
NPSH Required (NPSHR)

The minimum pressure required at the suction port of the pump to keep the pump from cavitation.

Net Positive Suction Head (NPSH)

Pressure can be converted into head with the following equation:

Head = pressure x 2.31/Specific gravity



Where:

h = Head, feet

p = Pressure, psi

SG = Specific gravity of the liquid Specific gravity

Fresh water is assigned a value of 1.0

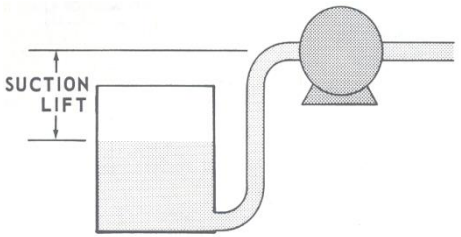
2.31 = a conversion factor. (2.31 feet of fresh water equals 1 psi.)

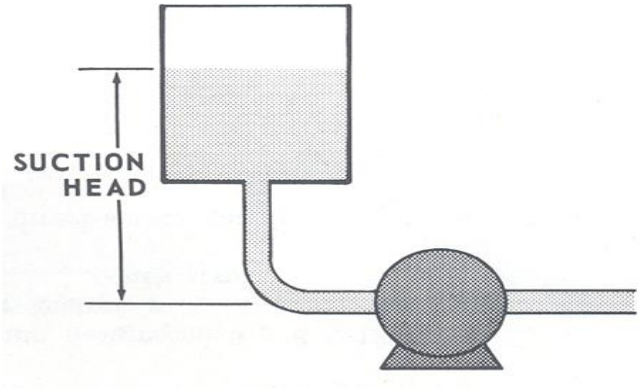
Total Head or Total Dynamic Head

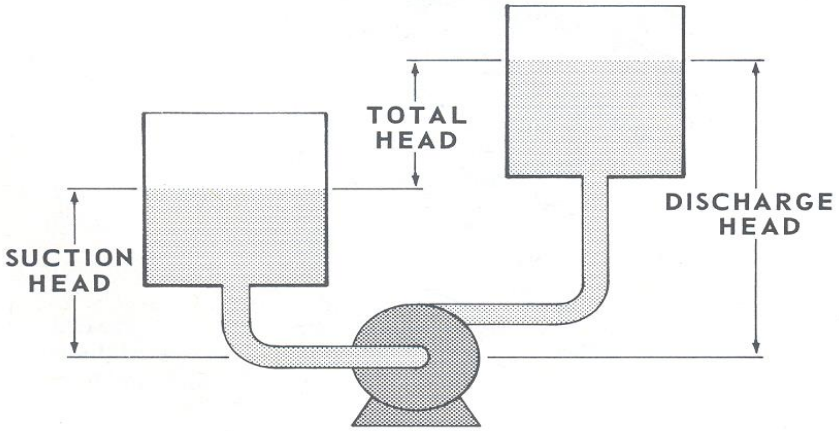
Total head (H), or total dynamic head (TDH), is the total dynamic discharge head minus the total dynamic suction head.

1- Total Head = discharge head - suction head.

2- Total Head = discharge head + suction lift







Pressure can be converted to head by the equations:

$$\text{Head (ft.)} = \frac{\text{Pressure (psi)} \times 2.31}{\text{Specific Gravity}}$$

$$\text{Head (m)} = \frac{\text{Pressure (kg/cm}^2\text{)} \times 10}{\text{Specific Gravity}}$$

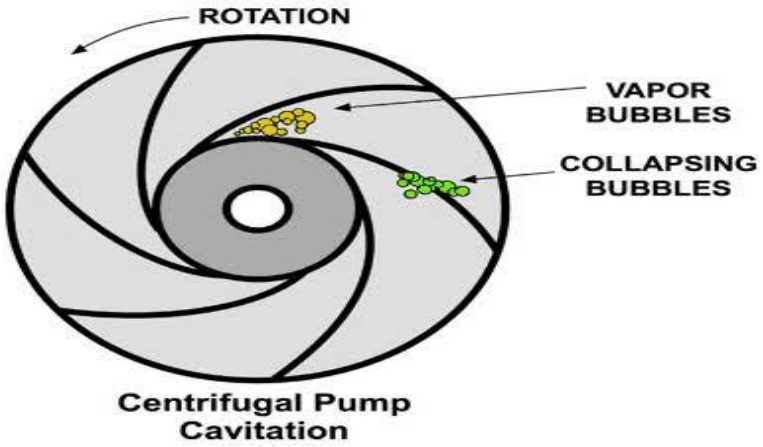
$$\text{Head (m)} = \frac{\text{Pressure (bar)} \times 10.2}{\text{Specific Gravity}}$$

Cavitation

- Cavitation is derived from the word “cavity” an empty space or a hollow space.
- If the suction pressure at the eye of the impeller falls below the vapor pressure of the fluid being pumped, the fluid will start to boil.
- Then bubble formation states in pump pipe and casing.
- The impeller and other pump components can be eroded over time.

How to Prevent Cavitation

- Reduce motor speed (RPMs)
- Install an impeller inducer.
- Increase liquid level around the suction area.


ROTATION
VAPOR BUBBLES
COLLAPSING BUBBLES
Centrifugal Pump Cavitation


Cavitation Damage
High Pressure
Low Pressure

Capacity

- The capacity (Q),In English units it is usually expressed in gallons per minute (GPM).
- In metric units it is expressed as liters per minute (l/min) or cubic meters per hour (m3/hour).

- The flow capacity of a centrifugal pump also depends on three other factors:

1) Pump Design Impeller
2) Diameter
3) Pump Speed

Common symptom

Centrifugal pump trouble shooting

No liquid delivery:

Possible cause

1) Instrument error
2) Not primed
3) Cavitation
4) Supply tank empty.

Liquid flow-rate low:

Possible cause

1) Instrument error
2) Cavitation
3) Inlet strainer clogged.

Centrifugal pump trouble shooting

Discharge pressure low:

Possible cause

1) Instrument error
2) Speed too low
3) Wrong direction of rotation (or impeller in backwards if double suction).

THANK YOU

RK RANA