CENTRIFUGAL PUMPS

Objectives

By the end of the session, the trainee will be able to :

- State the three functions of a centrifugal pump
- State what centrifugal force is and how it is applied to a pump
- Understand the terms ‘single stage’, ‘Multi-stage’, ‘vertical’ and ‘horizontal’ when applied to pumps
- Identify four basic types of Impeller
- Understand pumping problems, e.g. internal leakage, axial thrust
- Be able to identify the main component parts of a centrifugal pump
- State how flow and pressure are increased using centrifugal pumps, and understand the terms ▲P and ▲H

Centrifugal Pumps

There are three primary functions of a pump :

- To transfer liquids - ensure a specific flow
- To transfer a liquid from one level to a higher level
- To pump stored liquid from a low pressure to a higher pressure

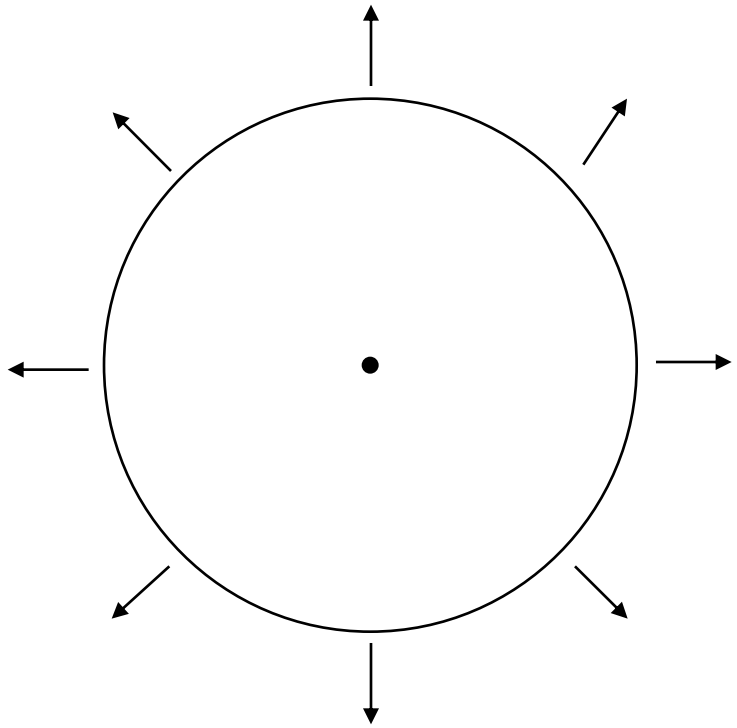
Centrifugal Pumps

What does 'centrifugal' mean ?

Moving away from the centre of axis

'Centrifugal Force' :

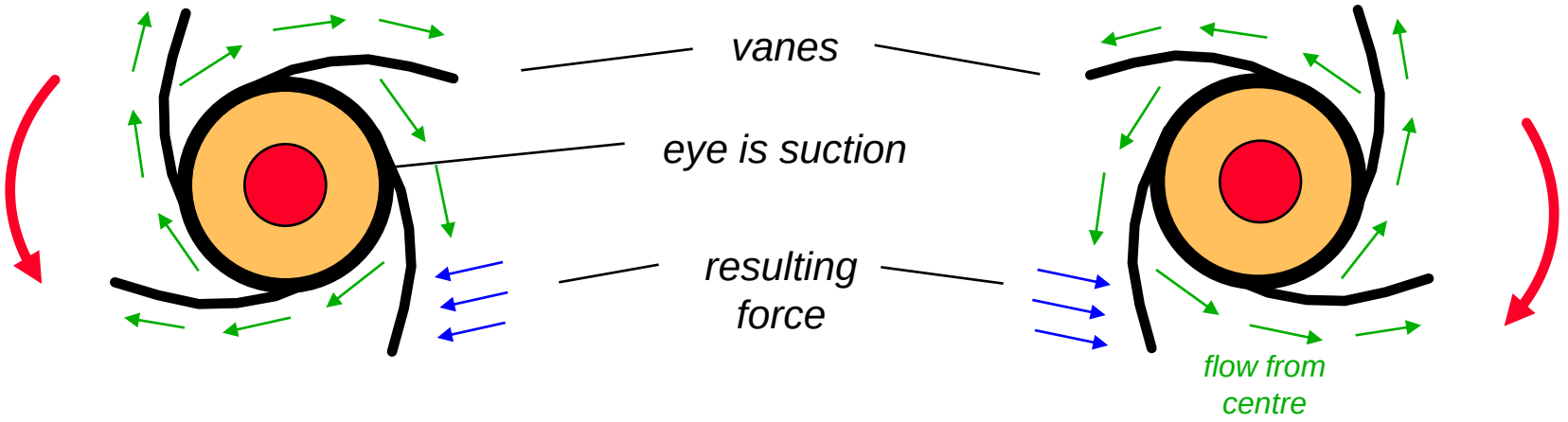
A force that appears to cause a body that is travelling round a centre to fly outwards and off its circular path



How does an Impeller Work ?

An Impeller rotates and draws in liquid through the centre or ‘eye’.

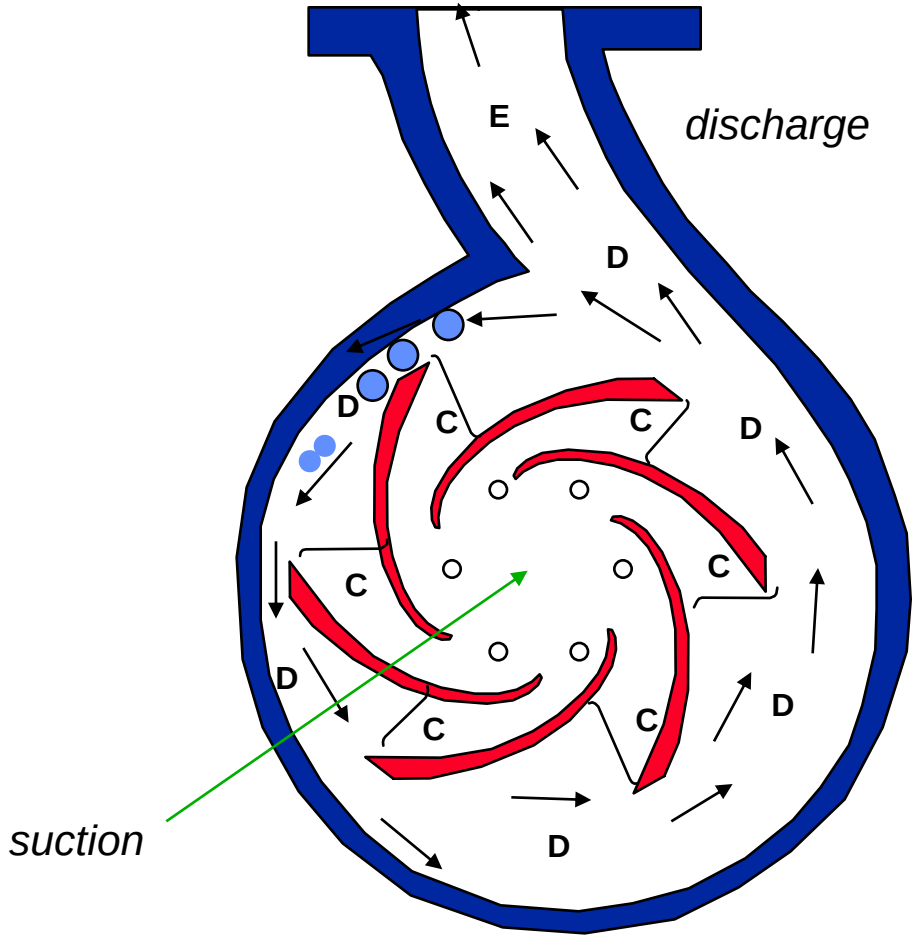
Impellers rotate in the direction opposite to the curvature of the vanes



If an impeller is as (A) and is screwed on shaft with a right hand thread, it will help to lock it on

Flow of liquid through a Pump

- The shape of a volute is similar to a snail shell.
- This allows for increase in volume until discharge
- Impellers rotate at between 1500 - 3000rpm
- Rotational speed of liquid is changed into pressure energy within the pump volute casing



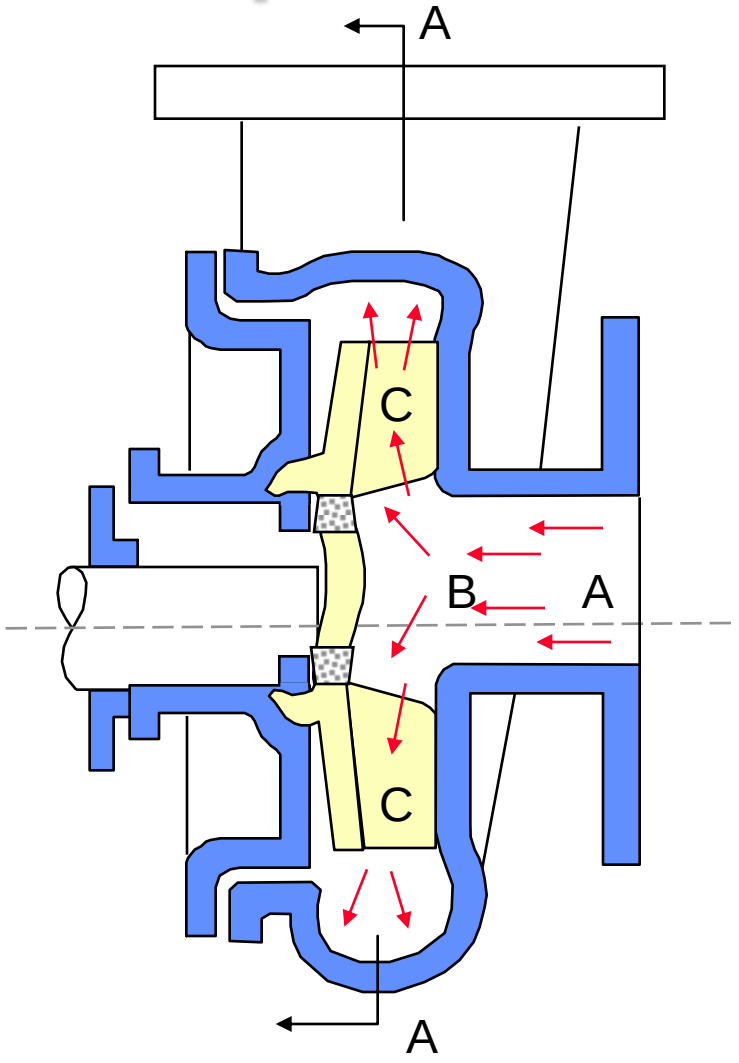
Centrifugal Pumps

Kinetic Energy (Speed)

↓

Pressure Energy

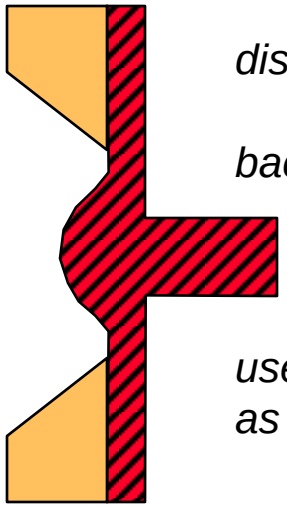
This change occurs in a pump due to the liquid at speed hitting the inside face of a volute casing and changing to pressure



Impellers

Various shapes dependent on application. Some variations are :

SEMI-OPEN



discharge

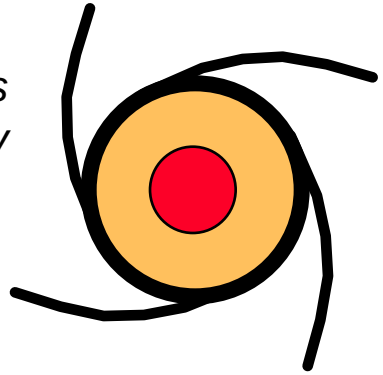
backing plate

suction

uses same as open type

OPEN

used for slurries or high viscosity liquids, i.e. bitumen

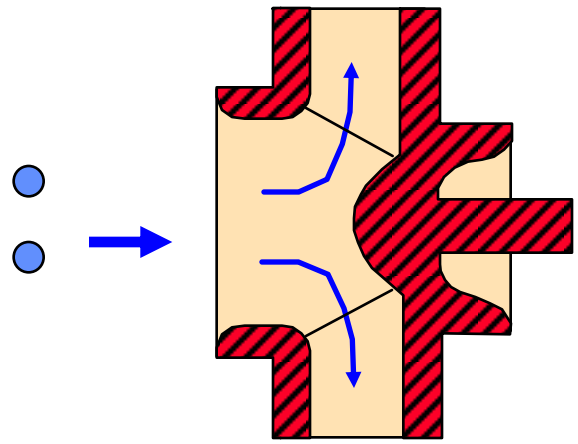


no axial thrust

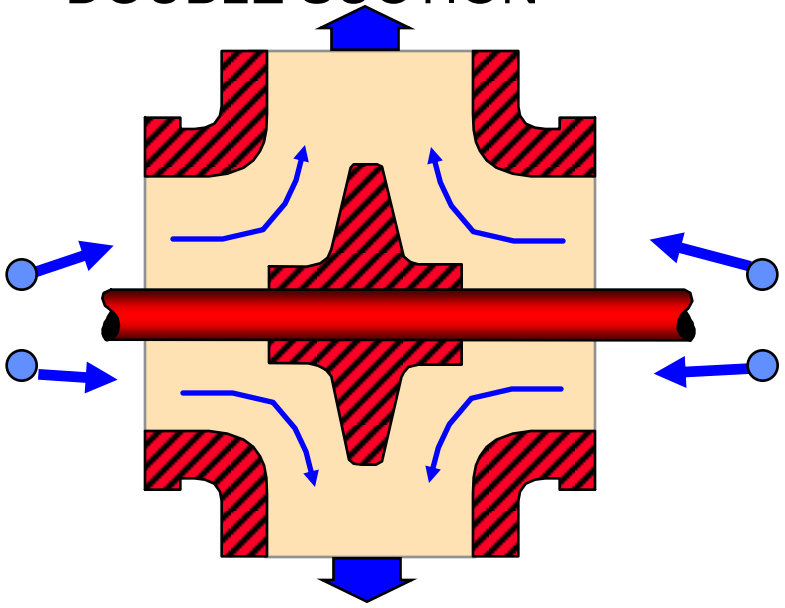
Disadvantage >> Creates axial thrust due to backing plate

Impellers

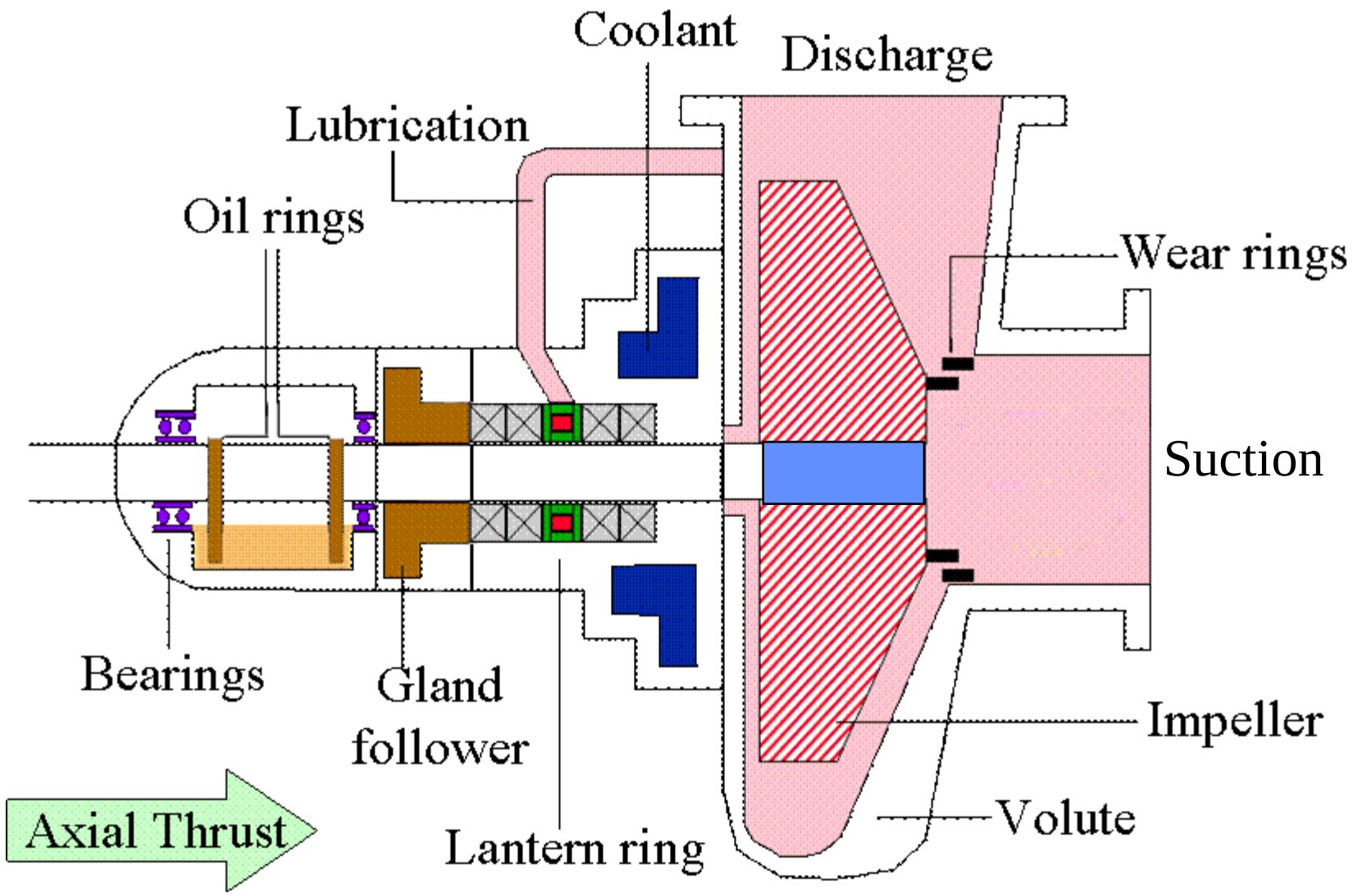
CLOSED



DOUBLE SUCTION



Used for increased volume pumping - i.e. water cooling for plant



Internal Problems - Internal Leakage

Can be minimised by using **Wear Rings**

Q : Where are they placed ?

A : 1) Between the impeller eye and the pump casing

2) Can also be used at the rear of the impeller

Q : What do they do ?

A : They minimise re-circulation from H.P. discharge to L.P. suction

Q : How are they lubricated ?

A : By the Process Liquid

Q : Why are they used ?

A : They reduce wear of the impeller and are cheaper to replace than the casing

Internal Problems

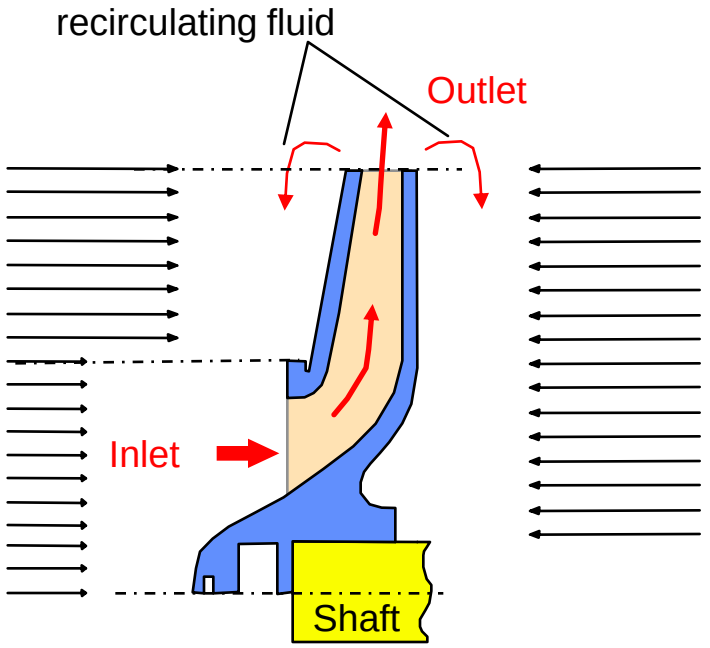
AXIAL THRUST

This is a phenomena that is experienced in most rotary machines. It must be minimised. There are a number of ways to do this within a centrifugal pump.

CENTRIFUGAL PUMPS

Forces acting on the discharge side of the impeller are greater than those acting on the suction side.

The resulting force is known as AXIAL THRUST

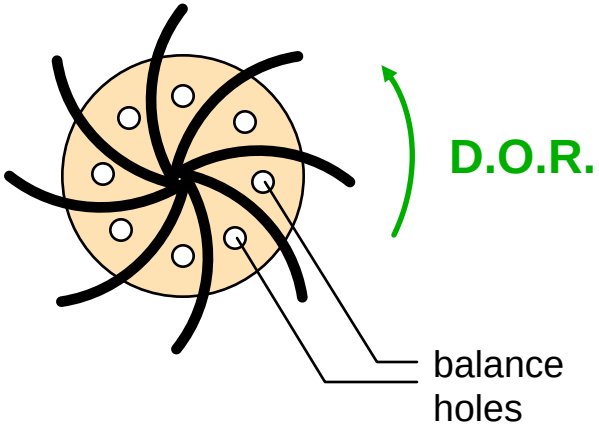


Axial Thrust - Remedies

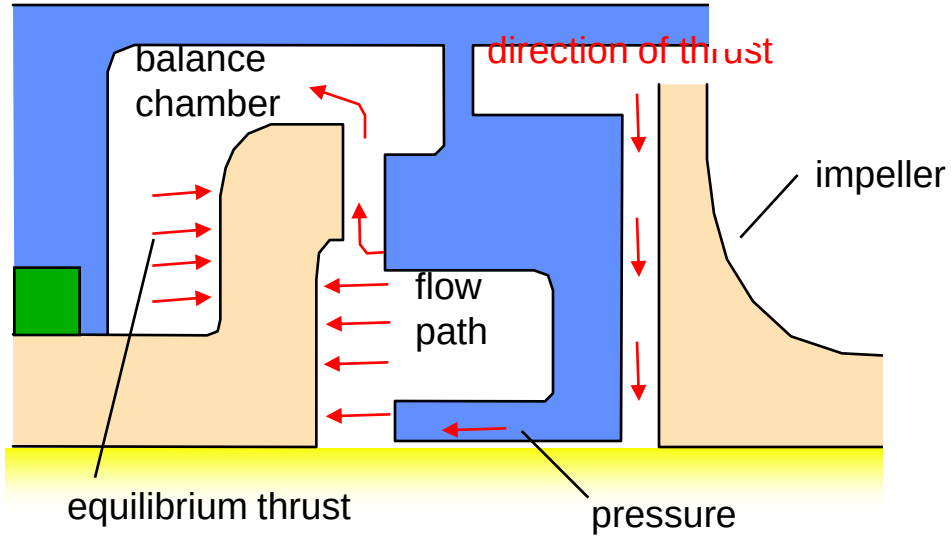
- Use thrust bearings placed near to the coupling
- Balance holes in impeller
- Balance piston
  (requires pump modification)

Axial Thrust - Balance Holes

Used in some pumps to correct this imbalance of forces and keep the impeller in the correct position



Balance Piston



Cavitation

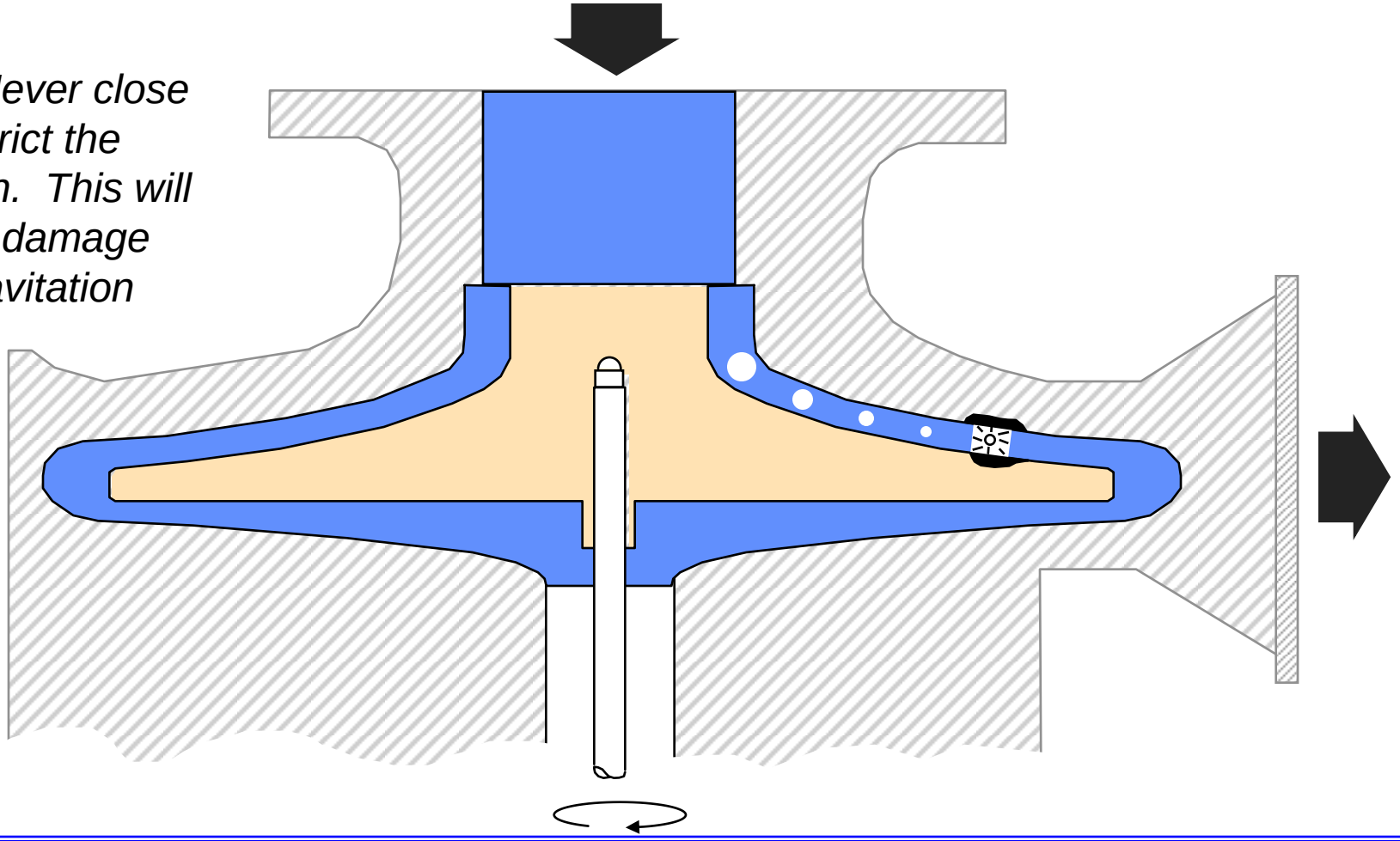
It is important to maintain a flow of liquid in a centrifugal pump suction. If not maintained, *overheating and and damage* mainly due to cavitation

WHAT IS CAVITATION ?

- Air / gas pockets form in the ‘eye’ of the impeller due to localised pressure drop
- As these bubbles accelerate along the impeller vanes, they implode due to the increased pressure, sometimes as high as 4400 Bar
- This violent implosion causes the material to break up
- The sound is similar to rolling stones
- If not eradicated, serious damage to bearings and driving components will result due to *vibration and wear*

Cavitation

NB : Never close or restrict the suction. This will cause damage and cavitation



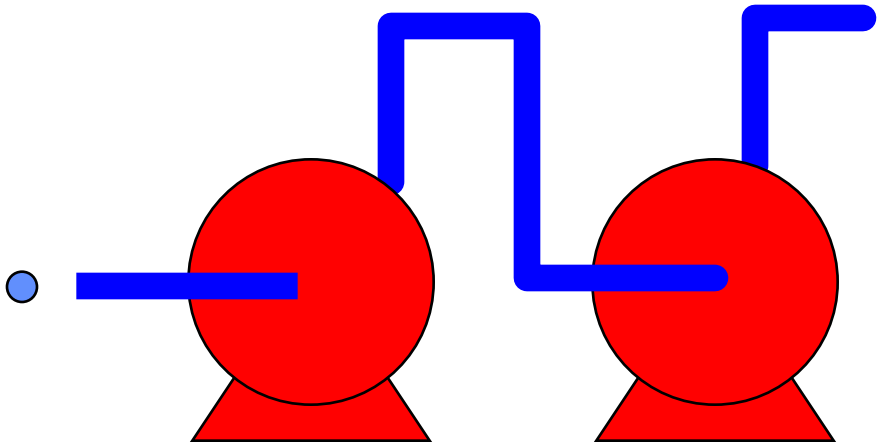
Centrifugal Pumps

- To increase pressure, three machine characteristics can be altered :
- Increase impeller diameter
- Increase the number of stages (Impellers)
- This can also be done by pumping in series
- Increase the speed of rotation

Increasing Pressure Output

PUMPING IN SERIES

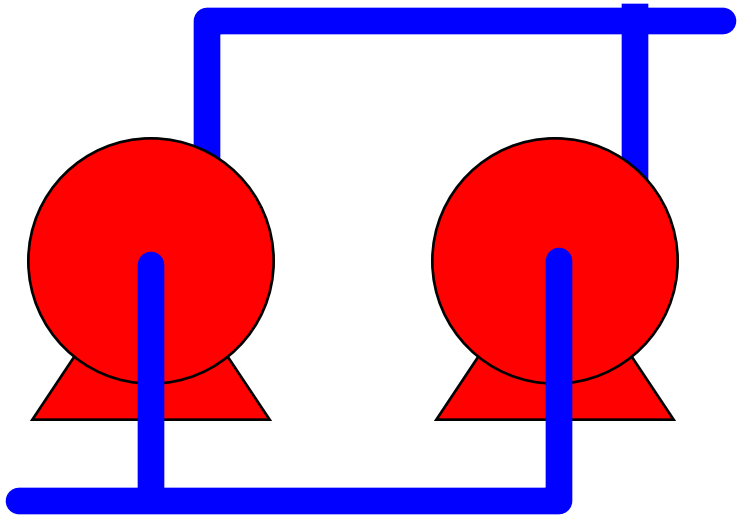
- The first pump is known as the Booster
- Two or more single stage pumps with the discharge of one pump connected to the suction of the next pump, etc. etc.



booster

Increasing Pressure Output

Increased flow rate can also be achieved by placing two or more pumps in parallel



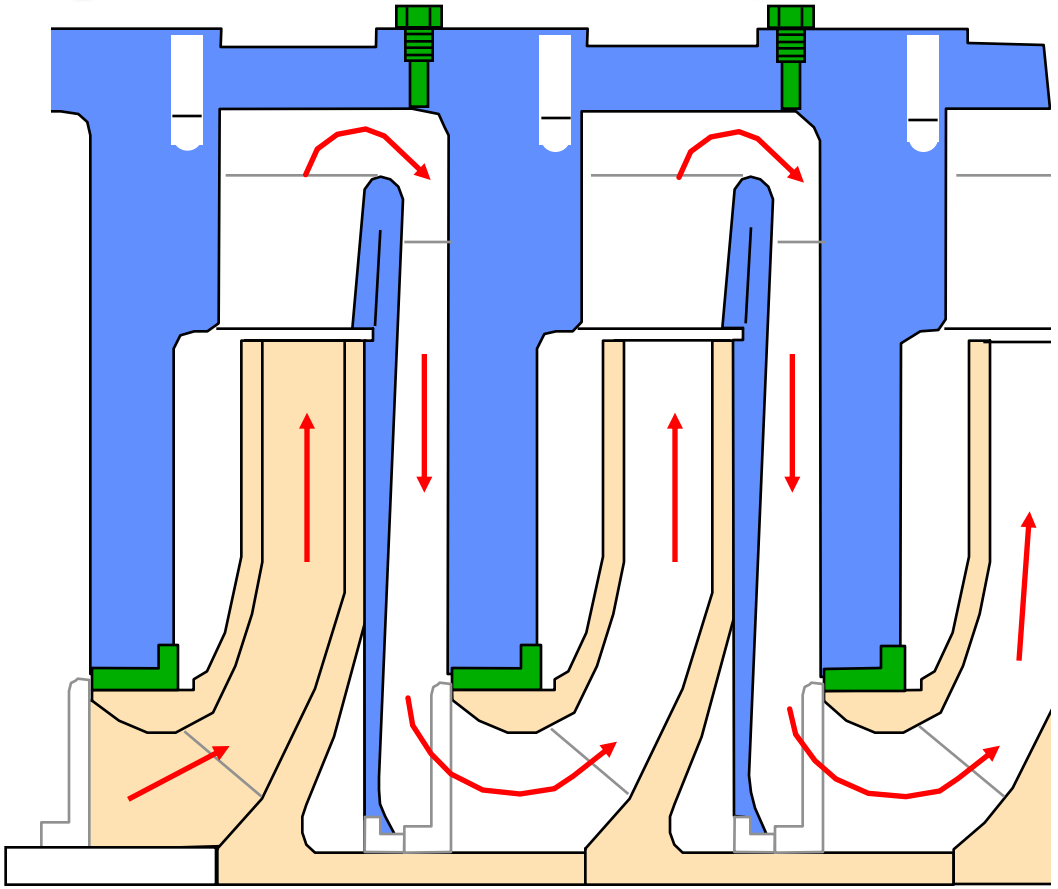
- Suction is achieved through a common suction line
- Discharge is into a common line
- Pumps must be of similar capacity
- Can be expensive compared to double suction to cost of pumps

Increasing Pressure Output

MULTI-STAGE PUMPING

A pump having more than one stage or impeller on one shaft

Discharge of one stage is connected to the suction of the next , etc.



Centrifugal Pumps

Differential Pressure

This is the differential between inlet & outlet pressures.

This difference is known as :

DELTA OR ▲P

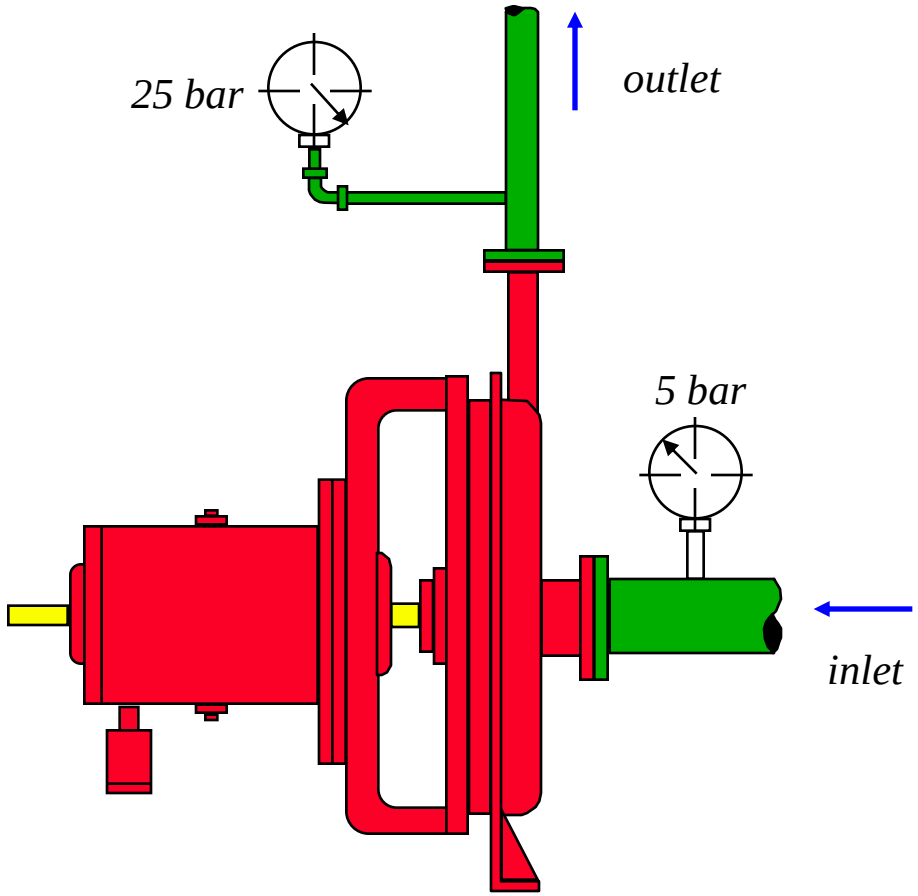
Example :

Outlet pressure = 25 bars

Inlet Pressure = 5 bars

▲P = 25 BARS - 5 BARS

▲P = 20 BARS



Differential Head ▲H

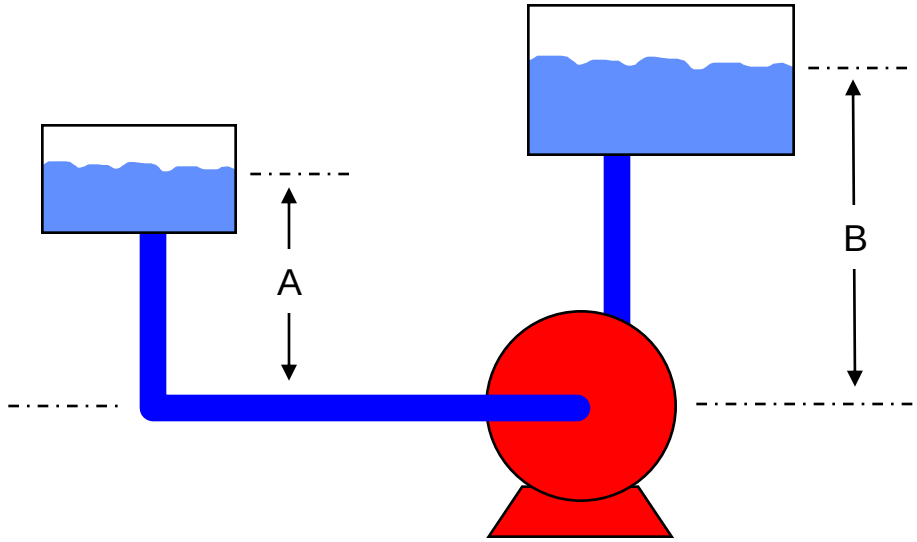
▲H = Static discharge head - Static suction head

A] STATIC HEAD

The distance from the free surface of the liquid to the centre of the pump at the suction head

B] STATIC DISCHARGE HEAD

The distance from the free surface of the liquid to the centre of the pump, at the discharge end



NB : It is important to maintain the static suction head. Failure to do this will result in serious damage to the pump due to ***cavitation***

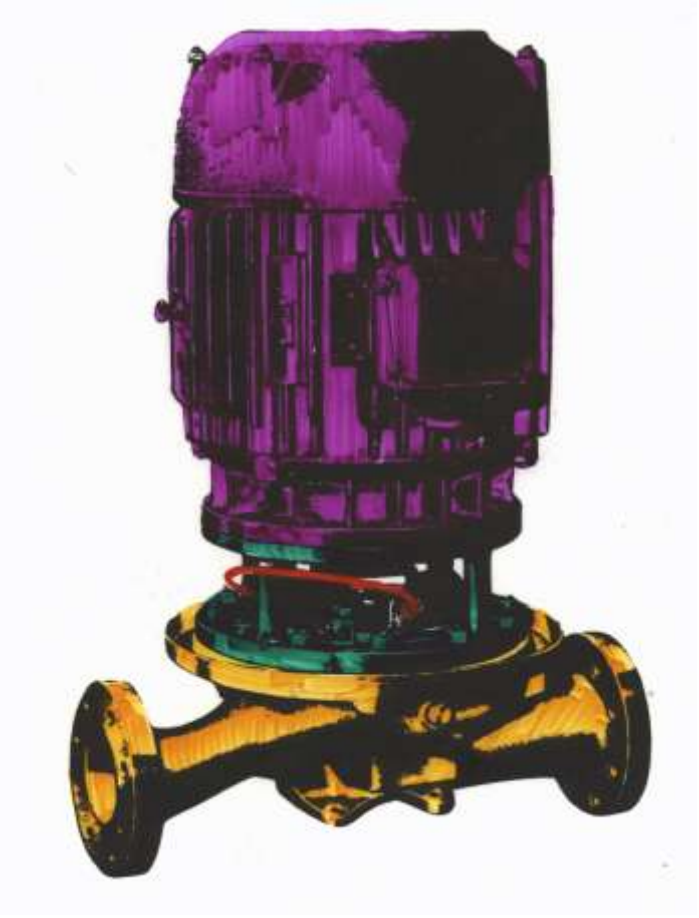
Overheating, vibration, metal fatigue

Centrifugal Pumps

Pumps can also be vertical or horizontal

Vertical - saves space

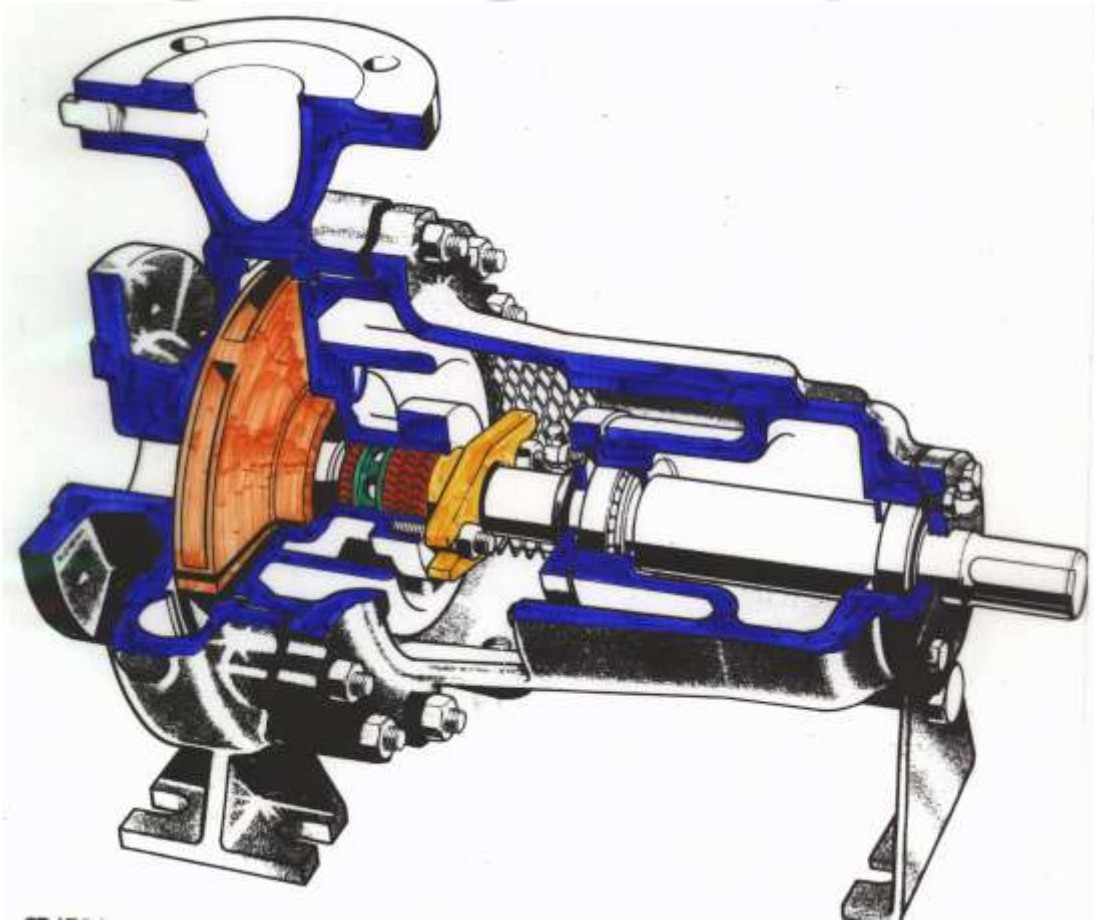
Pump from deep wells or increase suction head



What is a Single Stage Pump ?

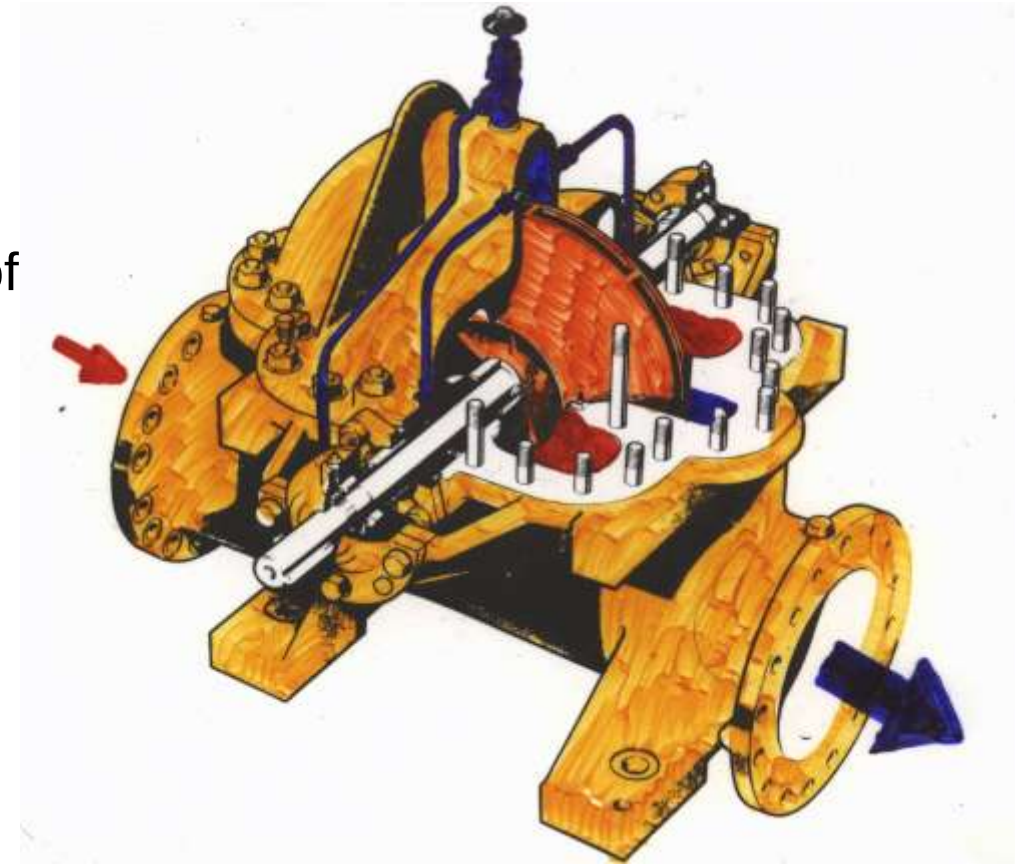
Single stage pumps are the most commonly used

A) One Impeller



Double Suction Pump

- This type of pump can be both horizontal and vertical
- Horizontal types tend to be of the split casing design
- This type of pump will give an increase in flow rate
- Axial thrust is minimal or non-existing due to balance



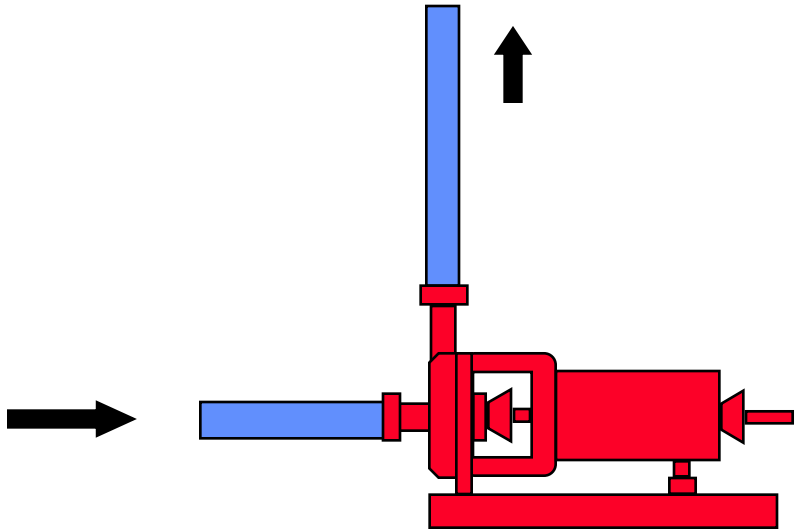
Centrifugal Pumps

In order to prolong the life of a pump, a number of problems must be overcome. These are :

- Correct shaft alignment
- Adequate lubrication (quality, quantity, frequency)
- Always maintain a good, positive suction. Never restrict the flow into a pump (Cavitation)
- Centrifugal pumps must always be primed before use
- Always consult the manufacturer's manuals and company engineering schedules while maintaining and installing (is it capable of doing the job it is required for)

Primary Functions of Centrifugal Pumps

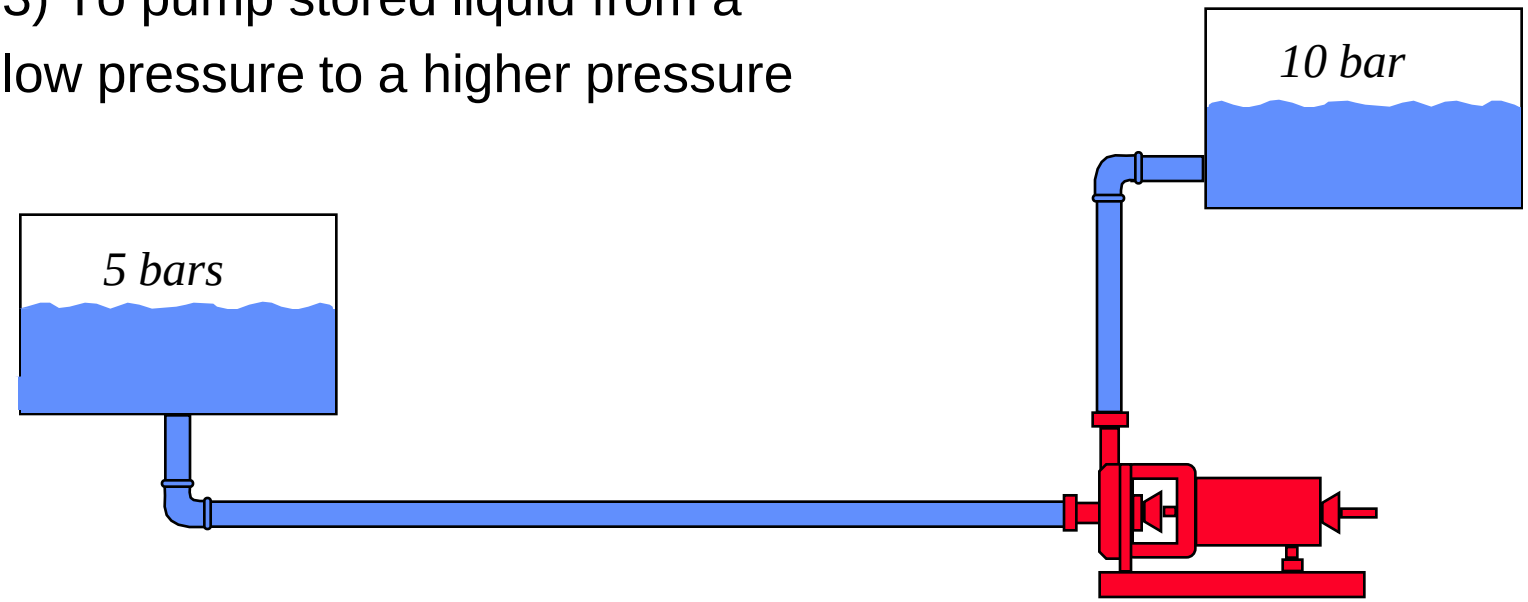
1) To transfer liquids - ensure a specific flow



360 P/Min

Primary Functions of Centrifugal Pumps

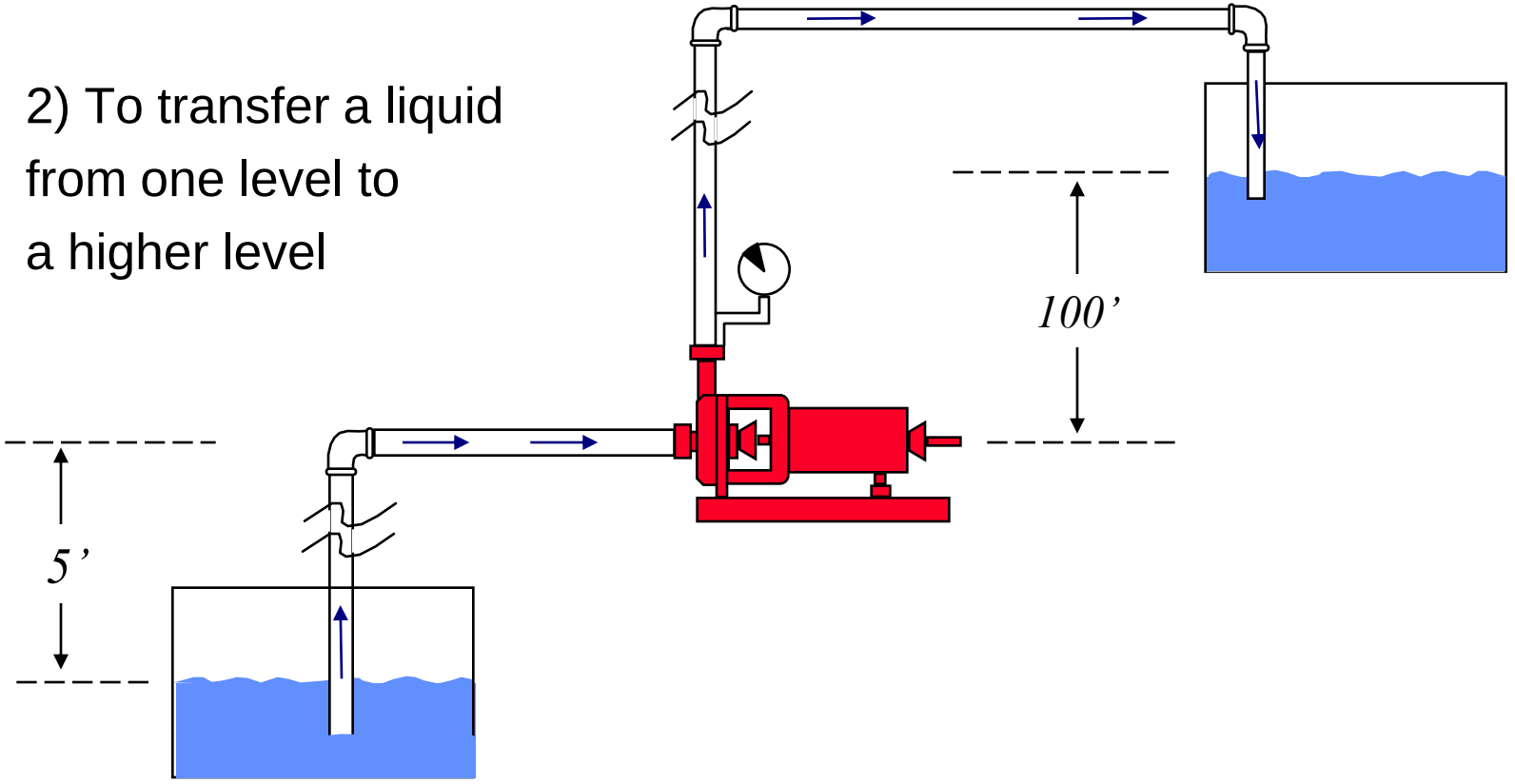
3) To pump stored liquid from a low pressure to a higher pressure



Centrifugal pumps can represent up to 80% of the total number of pumps used in a petrochemical plant

Primary Functions of Centrifugal Pumps

2) To transfer a liquid from one level to a higher level



Split Case 2 stage Pump