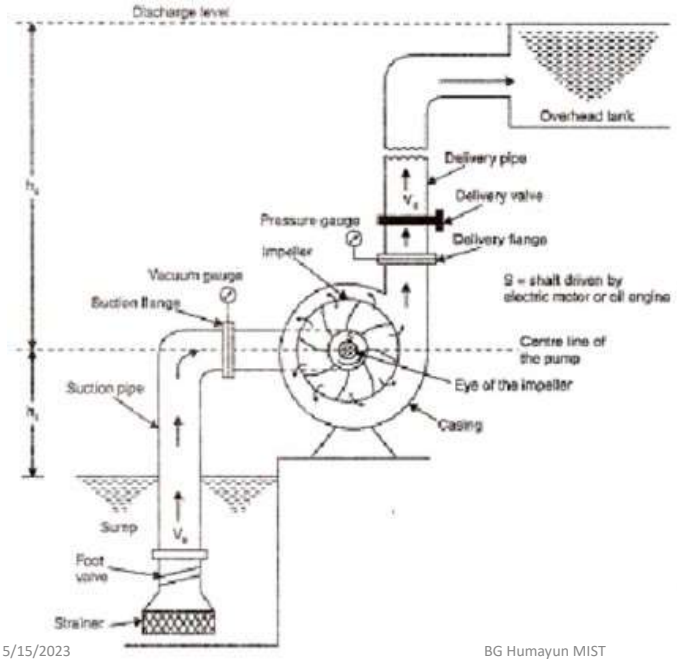
ME 161
Introduction to Mechanical Engineering
Lec Note 3: Brig Gen Humayun

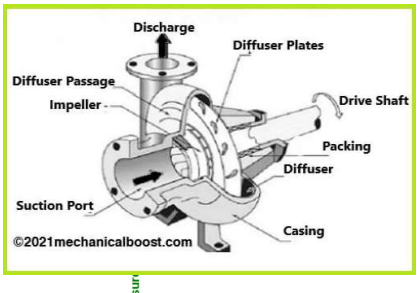
Please go through class notes and reference materials discussed in the class. This is just a guideline for those who missed the classes

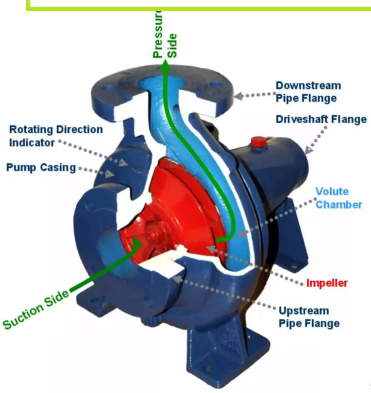
3. Fluid Machinery

Different Types of Pumps

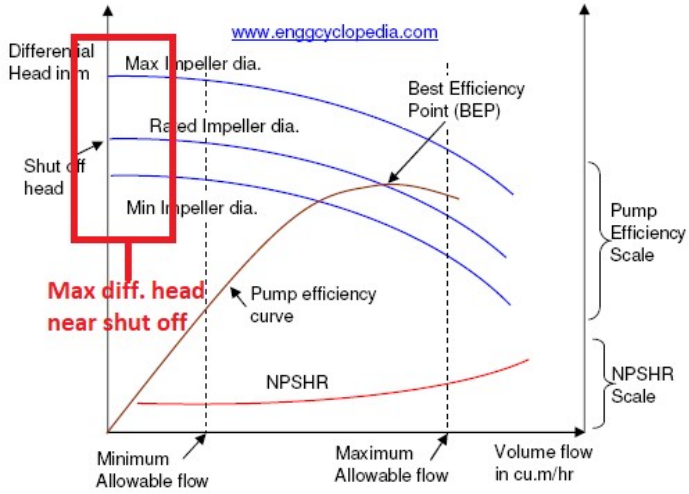
- Positive displacement pumps
  - Rotary Type
  - Gear Type
  - Reciprocating type
- Centrifugal Pumps
  - Axial Flow Pumps
  - Radial Flow Pumps
  - Horizontal Centrifugal Pumps
  - Vertical Centrifugal Pumps
  - Submersible Pumps



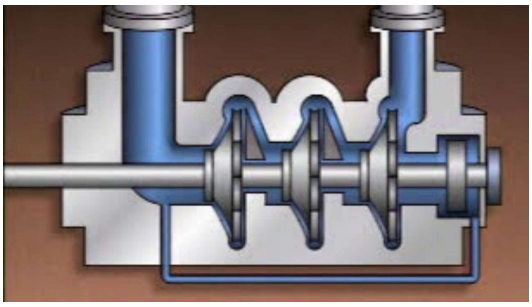


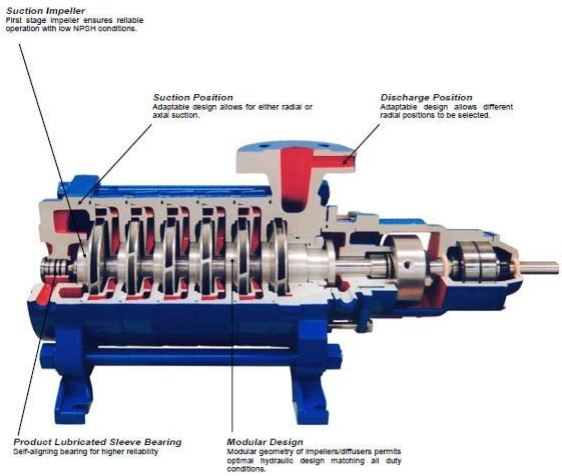


Centrifugal Pump Curve

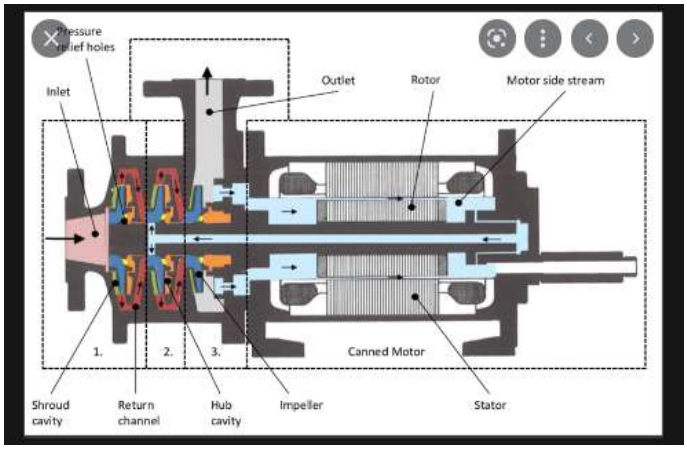


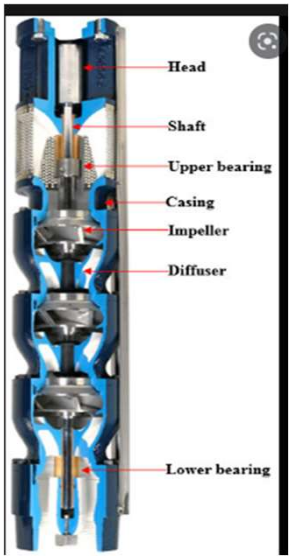
Stage Centrigugal pumps





Submersible pump

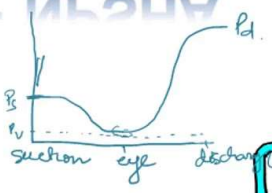




CALCULATION OF NPSHA

NPSH

To avoid cavitation, the pressure at the pump inlet must exceed the vapor pressure by certain value, called net positive suction head



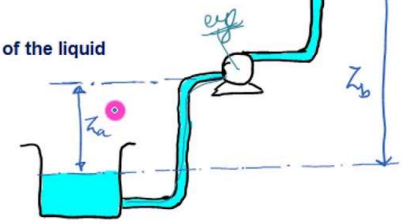
NPSHA

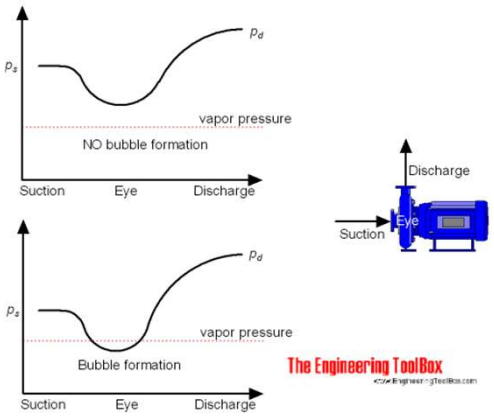
NPSHA=Liquid pressure at pump suction- Vapor pressure of the liquid

NPSHR

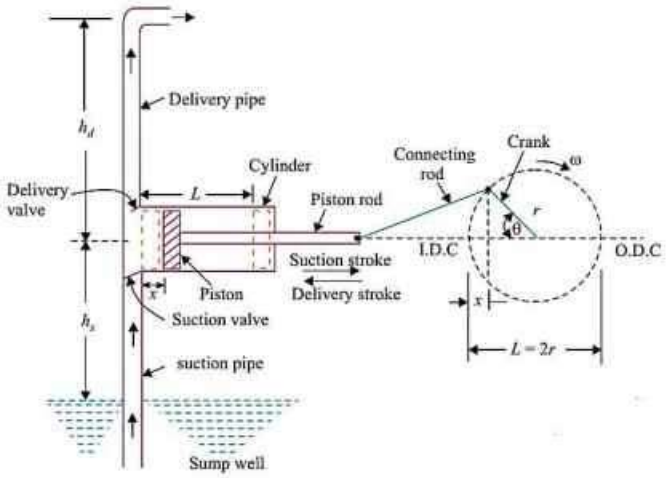
NPSHR=Minimum required net positive suction head.

It is specified by vendor/manufacturer





NPSH = P_s - P_{vap}
Where:
NPSH = NPSH available from the system, at the pump inlet, with the pump running
P_s = Stagnation suction pressure, at the pump inlet, with the pump running
P_{vap} = Vapor pressure of the pumpage at inlet temperature



A **reciprocating pump** is a class of positive-displacement pumps that includes the piston pump, plunger pump, and diaphragm pump.

In reciprocating pumps, the chamber that traps the liquid is a stationary cylinder that contains a piston or plunger.

Basic Components of a Reciprocating Pump

- Water reservoir - it is not a part of reciprocating pump, however, it is the main source where from the reciprocating pump takes the water. It may be a source of other fluid as well.
- Strainer - It removes all impurities from the liquid to avert chocking the pump.
- Suction Pipe - It is a pipe by which pump takes the water from the reservoir.
- Suction Valve - It is a non-return type valve installed on the suction pipe and helps to flow from reservoir to pump not the vice versa.
- Cylinder or liquid cylinder - The main component where pressure is increased. It is a hollow cylinder with coatings. It consists of a piston along with piston rings.
- Piston or plunger and Piston rod - Piston is directly connected to a rod that is the piston rod. This piston rod is again connected to the connecting rod. Piston makes the reciprocating motion in forward and backward motion and creates pressure inside the cylinder.
- Piston rings - Piston rings are small but one of the vital parts to protect the piston surface as well as cylinder inner surface from wear and tear. It helps to operate the pump smoothly.
- Packing - Packing is necessary for all pumps, to have a proper sealing between cylinder and piston. It helps to stop leakage.
- Crank and Connecting rod - Crank is connected to the power source and connecting rod makes connection between crank and piston rod. These component helps to change the circular motion into linear motion.
- Delivery valve (non-return valve) - Like suction valve delivery valve is also non return type and it helps to built up the pressure. It protect the pump from back flow.
- Delivery pipe - It helps to supply the fluid at destination.
- Air Vessel - Few reciprocating pumps may have an air vessel, it helps to reduce the frictional head or acceleration head.

Oil Pump

Driven by camshaft, crankshaft
All types of oil pumps use a pick-up screen in the sump and a pressure regulator.

•Rotor Pump*(Two star shaped rotors pump the oil)*

•Gear Pump

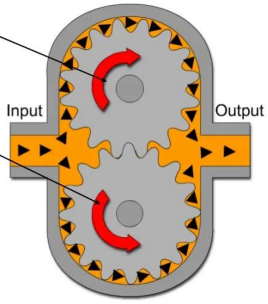
Gear Pump

Pump shaft drives one gear.

Other gear rotates.

Low pressure at input.

High pressure at output.

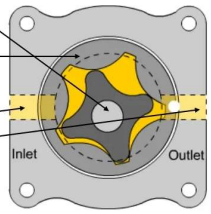


Rotary Oil Pump

Inner rotor driven by pump shaft.

Inner rotor drives outer rotor.

Oil is forced from input to output



May be shaft, gear or chain driven.

Difference between Fans, Blowers and Compressors

Fans, blowers and compressors are differentiated by the method used to move the air, and by the system pressure they must operate against. As per American Society of Mechanical Engineers (ASME) the specific ratio - the ratio of the discharge pressure over the suction pressure

Fans, Blowers and Compressors

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Difference Between Fans, Blower and Compressors		
Equipment	**Specific Ratio**	**Pressure Rise (mmWC)**
Fans	Up to 1.11	1136
Blowers	1.11 to 1.20	1136 to 2066
Compressors	More than 1.20	

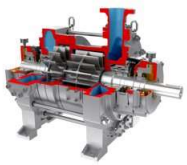
As per American Society of Mechanical Engineers (ASME) the specific ratio – *the ratio of the discharge pressure to the suction pressure* – is used for defining the fans and blowers

COMPRESSOR

Scroll

Screw

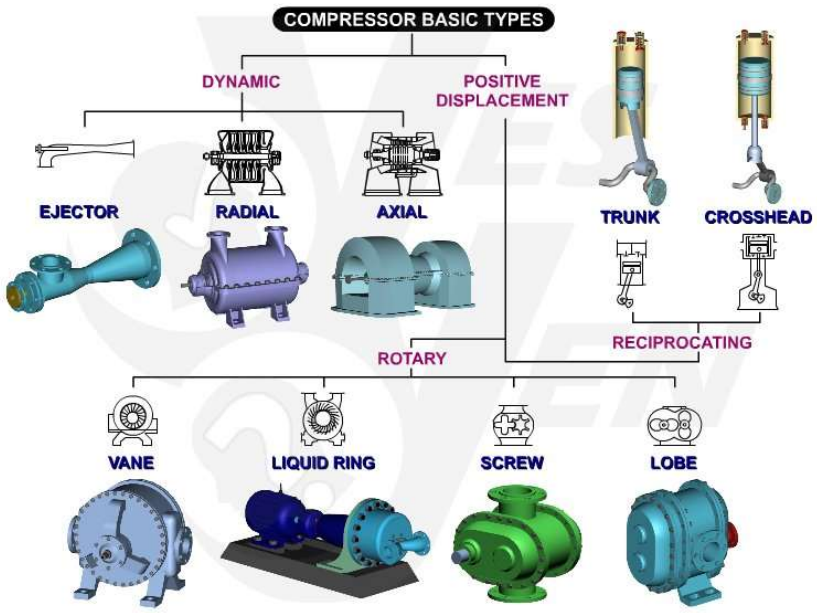
Reciprocating



Liquid-Ring

Rotary-Lobe

Rotary-Vane



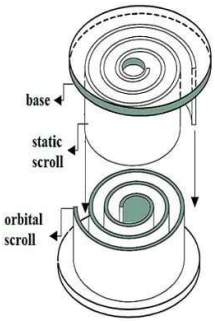
Scroll compressor

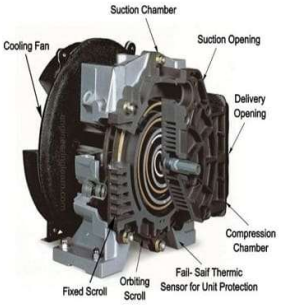
(a) Vapour refrigerant enters an outer pocket

(b) The pocket is sealed off and compression starts

(c) The pocket is reduced in size

(d) As the pocket reaches the centre, the discharge port is uncovered and discharges the compressed vapour refrigerant



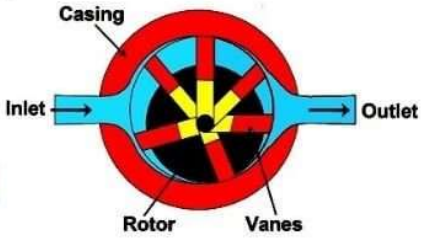


Vane Compressor

Vane Blower Compressor | Construction of Vane Compressor | Working of Vane Compressor

One of the oldest compressor technologies, rotary vane compressors consist of a rotor with a number of blades inserted in radial slots in the rotor.

Vane Compressor



Example 1

mass = 1kg
speed = 120 rpm
radius = 0.25m

$F = 1kg \cdot \left[2 \cdot \pi \left(\frac{120rpm}{60}\right)\right]^2 \cdot 0.25m$

$F = 39.4\ N$

$v = 0.25m \cdot 2 \cdot \pi \left(\frac{120rpm}{60}\right)$

$v = 3.14m/s$

Example 2

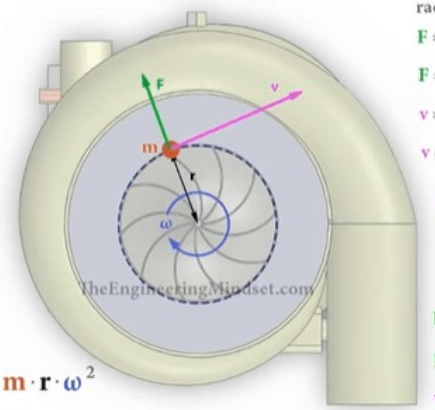
mass = 1kg
speed = 120 rpm
radius = 0.5m

$F = 1kg \cdot \left[2 \cdot \pi \left(\frac{120rpm}{60}\right)\right]^2 \cdot 0.5m$

$F = 78.8\ N$

$v = 0.5m \cdot 2 \cdot \pi \left(\frac{120rpm}{60}\right)$

$v = 6.28m/s$



F = Centrifugal force (N)
v = Tangent velocity (m/s)
r = Radius (m)
ω = Angular velocity (rpm)
m = Mass (kg)

$F = m \cdot r \cdot \omega^2$

$v = r \cdot \omega$

Example 3

mass = 1kg
speed = 169.5rpm
radius = 0.25m

$F = 1kg \cdot \left[2 \cdot \pi \left(\frac{169.5rpm}{60}\right)\right]^2 \cdot 0.25m$

$F = 78.8\ N$

$v = 0.25m \cdot 2 \cdot \pi \left(\frac{169.5rpm}{60}\right)$

$v = 4.43\ m/s$