DEPARTMENT OF AGRICULTURAL ENGINEERING

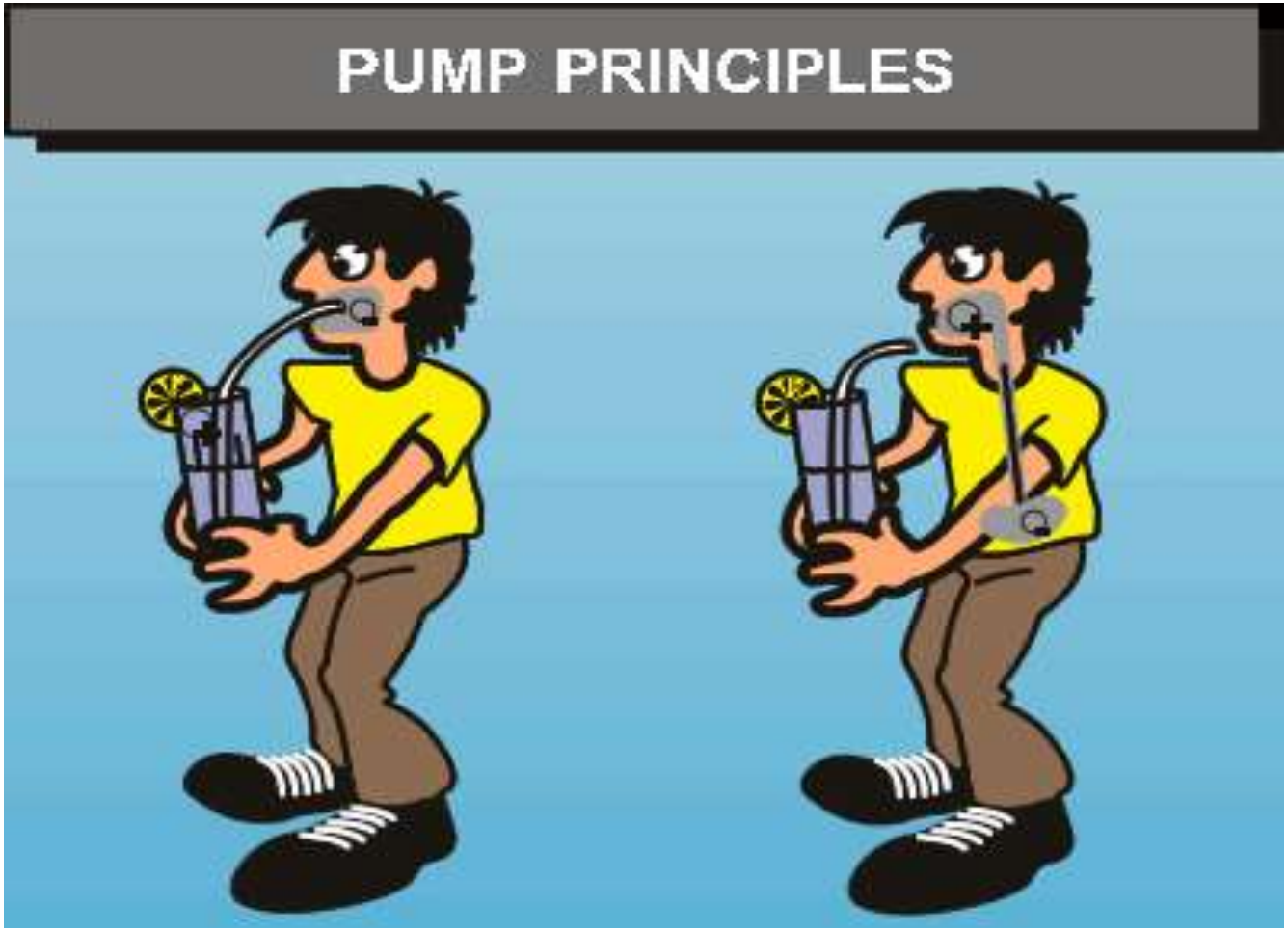
COURSE CODE & NAME: 19MEB201 & FLUID MECHANICS AND MACHINERY

II YEAR / III SEMESTER

UNIT -IV

TOPIC : CENTRIFUGAL PUMP

PRINCIPLE OF PUMP



Convert the mechanical energy into hydraulic energy by centrifugal force on the liquid. Constitute the most common type of pumping machinery, Used to move liquids through a piping system

- Has two main components:

  1. Stationary componets, casing, casing cover and bearings.

  2. Rotating components, impeller and shaft

- Classified into three categories : Radial Flow, Mixed Flow, Axial Flow.

WORKING MECHANISM OF A CENTRIFUGAL PUMP

- Simplest piece of equipment in any process plant
- Energy changes occur by virtue of impeller and volute
- Liquid is fed into the pump at the center of a rotating impeller and thrown outward by centrifugal force
- The conversion of kinetic energy into pressure energy supplies the pressure difference between the suction side and delivery side of the pump

Centrifugal pump works on the principle that when a certain mass of liquid is made to rotate along the impeller from the central axis of rotation, it impresses a centrifugal head.

It causes the water to move radially outwards at higher velocity and causes the water to rise to a higher level.

The motion of water is restricted by casing of pump, it result into pressure build up.

In addition , the change in angular momentum of liquid during its flow results into increase in pressure head.

The steps involved in operation of centrifugal pump are as follows :

✓The delivery valve is closed. The priming of the pump is carried out. Priming involves the filling the liquid in suction pipe and casing upto the level of delivery valve so that no air pockets are left in the system. if any air or gas pockets are left in this portion of pump, it may result into no delivery of liquid by the pump.

✓The pump shaft and impeller is now rotated with the help of an external source of power like a motor or any other prime mover.

✓ The rotation of impeller inside a casing full of liquid produces a forced vortex which is responsible in imparting the centrifugal head to the liquid. It creates a vaccum at the eye of impeller and causes liquid to rise into suction pipe from the sump.

- ✓ The speed of impeller should be sufficient to produce the centrifugal head such that it can initiate discharge from delivery pipe.
- ✓ Now the delivery valve is opened and the liquid is lifted and discharge through the delivery pipe due to its high pressure.
- ✓ Thus the liquid is continuously sucked from the sump to impeller eye and it is delivered from the casing of pump through the delivery pipe.
- ✓ Before stopping the pump, it is necessary to close the delivery pipe otherwise the back flow of liquid may take place from the high head reservoir.

Self Priming of Centrifugal Pump:

- ✓ The operation of filling the casing , impeller and suction pipe and the portion of delivery pump up to delivery valve is called priming.
- ✓ 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. 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

CENTRIFUGAL PUMP

❖The mechanical energy is converted, into pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called centrifugal pump

❖A **centrifugal pump** is a rotodynamic pump that uses a rotating impeller to increase the pressure of a fluid.

❖Centrifugal pumps are commonly used to move liquids through a piping system.

❖The fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller, flowing radially outward into a diffuser or volute chamber (casing), from where it exits into the downstream piping system.

❖Centrifugal pumps are used for large discharge through smaller heads.

PARTS OF PUMP

Impeller

- The rotating part of a centrifugal pump is called ‘impeller’.
- It is a wheel with series of backward curved vanes.
- The impeller is mounted on a shaft which is connected to the shaft of an electric motor.
- Main rotating part that provides centrifugal acceleration to the fluid ,
- Number of impellers = number of pump stages
- Impeller classification: direction of flow, suction type and shape/mechanical construction

Shaft

- Transfers torque from motor to impeller during pump start up and operation

CASINGS

Functions

- Enclose impeller as “pressure vessel”
- To prevent external leakage.
- To guide water to and from the impeller.
- To partially convert K.E to P.E.

Volute case

- Impellers inside casings, gradually increase from impeller to D.P.
- To reduce the velocity of flow.
- Balances hydraulic pressure on pump shaft

Suction pipe.

- It connects the Centre of the impeller to sump.
- To check the formation of air pockets the pipe laid air tight.
- The lower end of the pipe is also fitted with non- return foot valve, which does not permit the liquid to drain out of the suction pipe, when pump is not working.

Strainer- To prevent the solid particles, debris.

Delivery pipe:

It is connected at its lower end to the outlet of the pump and delivers the liquid to the required height.

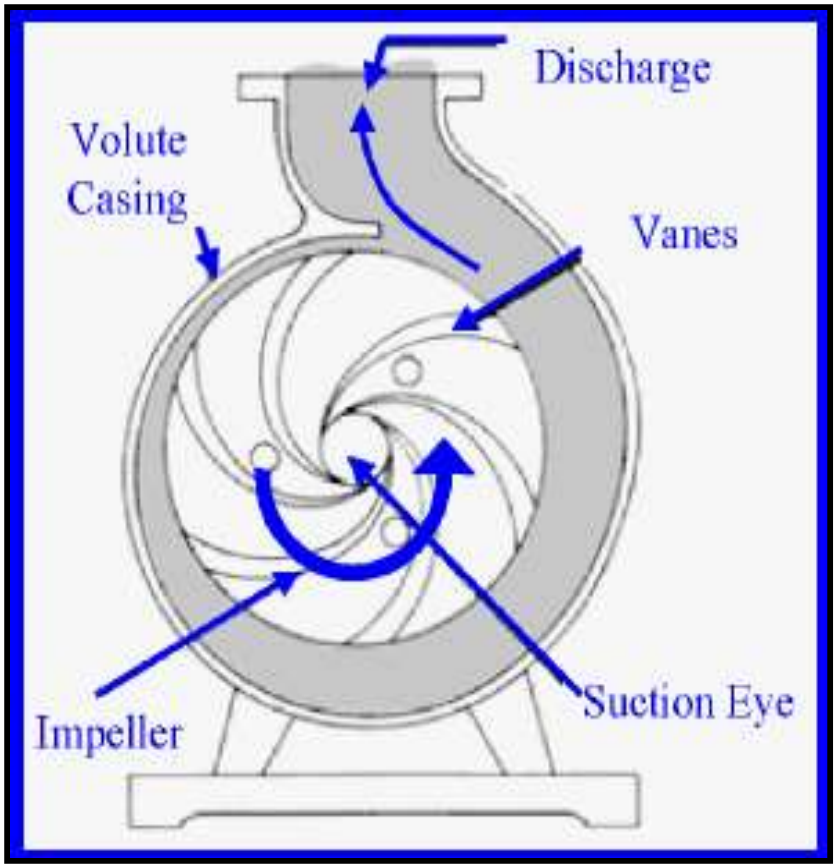
Impeller Mechanism Pump

WORKING

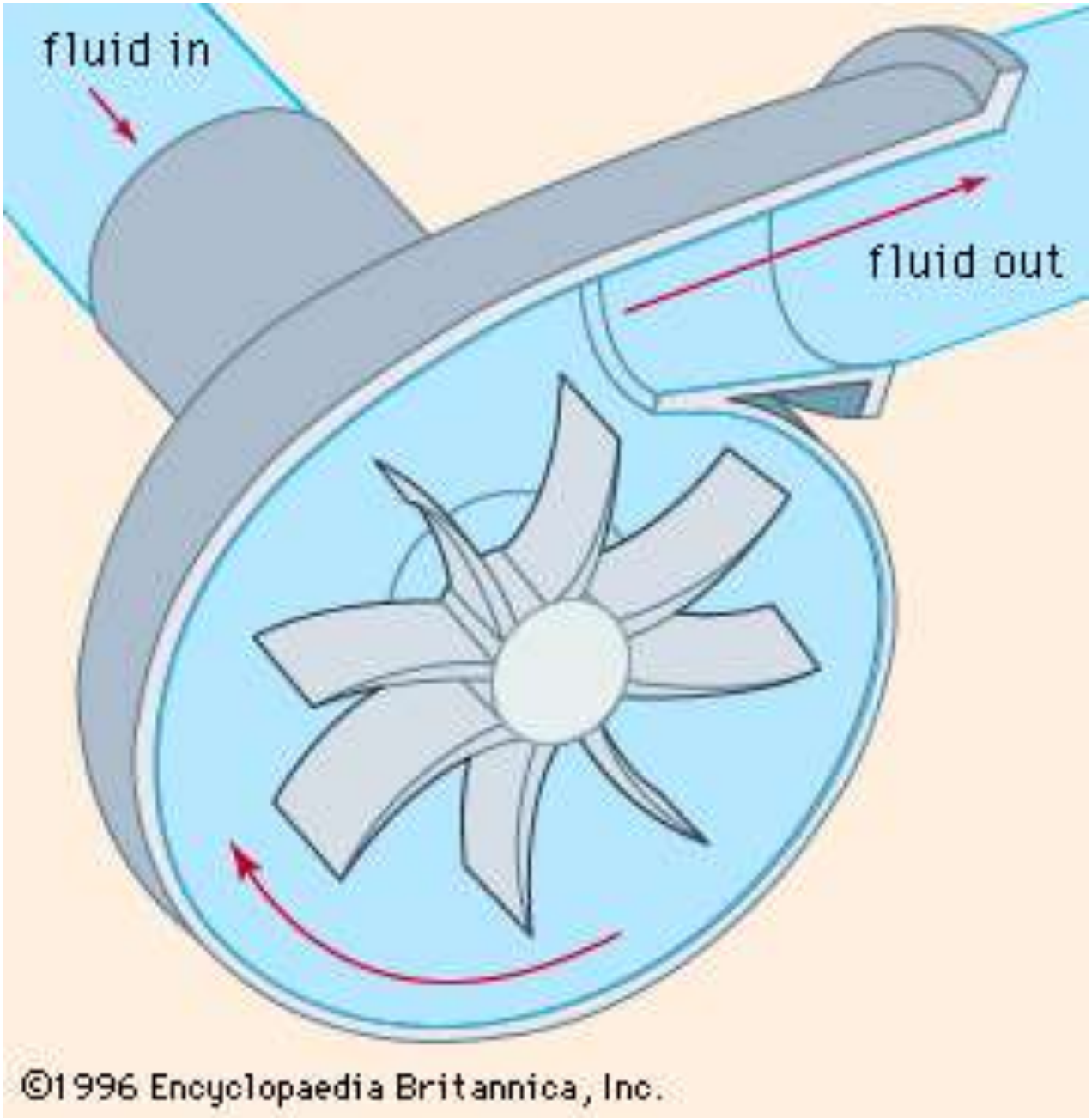
- The delivery valve is closed and the pump is primed.
- Suction pipe , casing and portion of the delivery pipe upto the delivery valve are filled liquid, so that no pocket is left.
- Delivery valve is closed, the electric motor is started to rotate the impeller.
- The speed of the impeller is gradually increased till the impeller rotates at normal speed.
- After the impeller attains the normal speed, the delivery valve is opened, when the liquid is continuously sucked. This liquid is impelled out by the rotating vanes and its comes out the outlet tips of the vane into the casing.
- The liquid passes into pipe and is lifted to the required height.

- ✓ Liquid is fed into the pump at the center of a rotating impeller and thrown outward by centrifugal force.
- ✓ The conversion of kinetic energy into pressure energy supplies the pressure difference between the suction side and delivery side of the pump

HOW IT WORKS



- Liquid forced into impeller
- Vanes pass kinetic energy to liquid: liquid rotates and leaves impeller
- Volute casing converts kinetic energy into pressure energy


fluid in
fluid out
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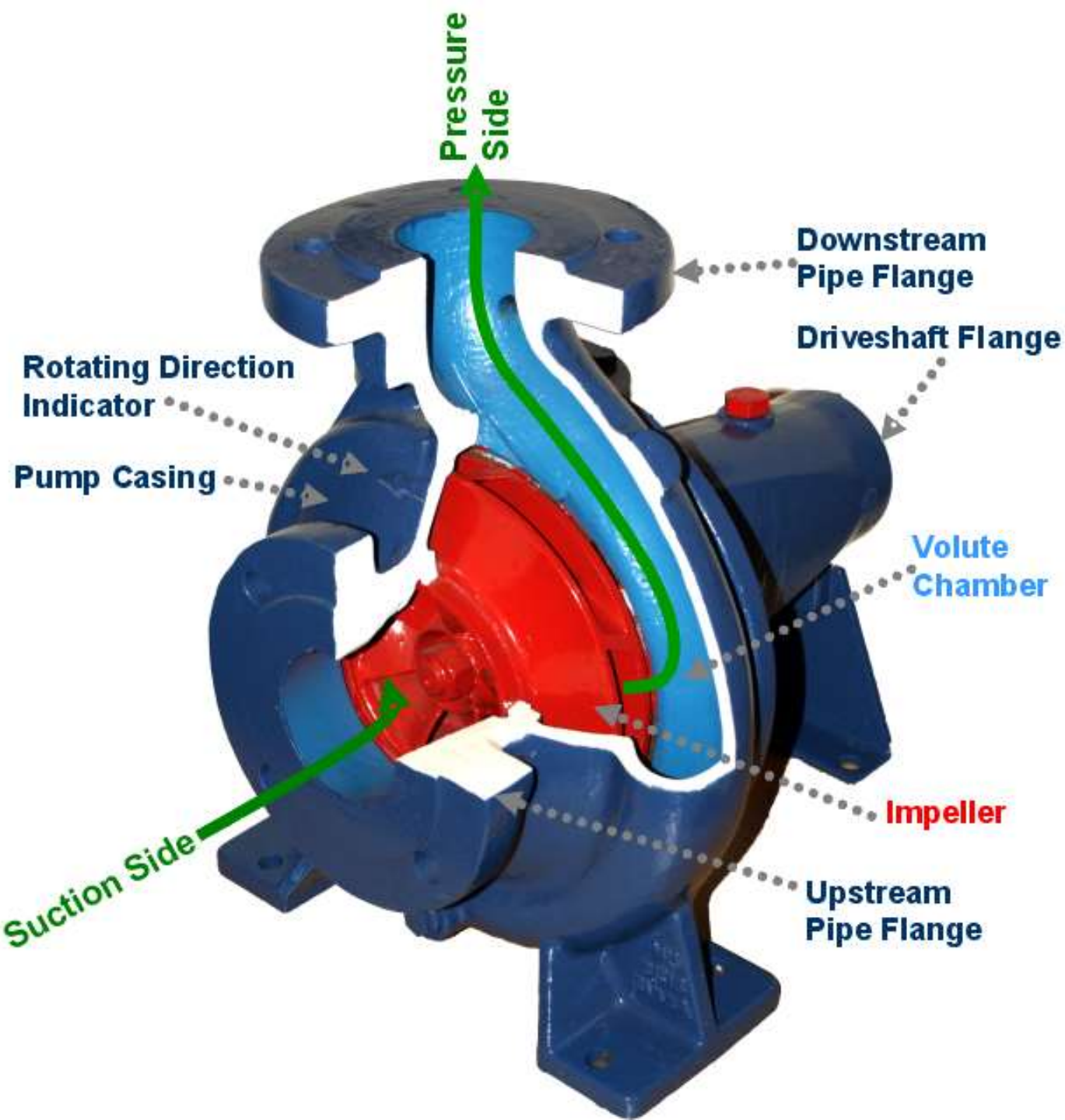
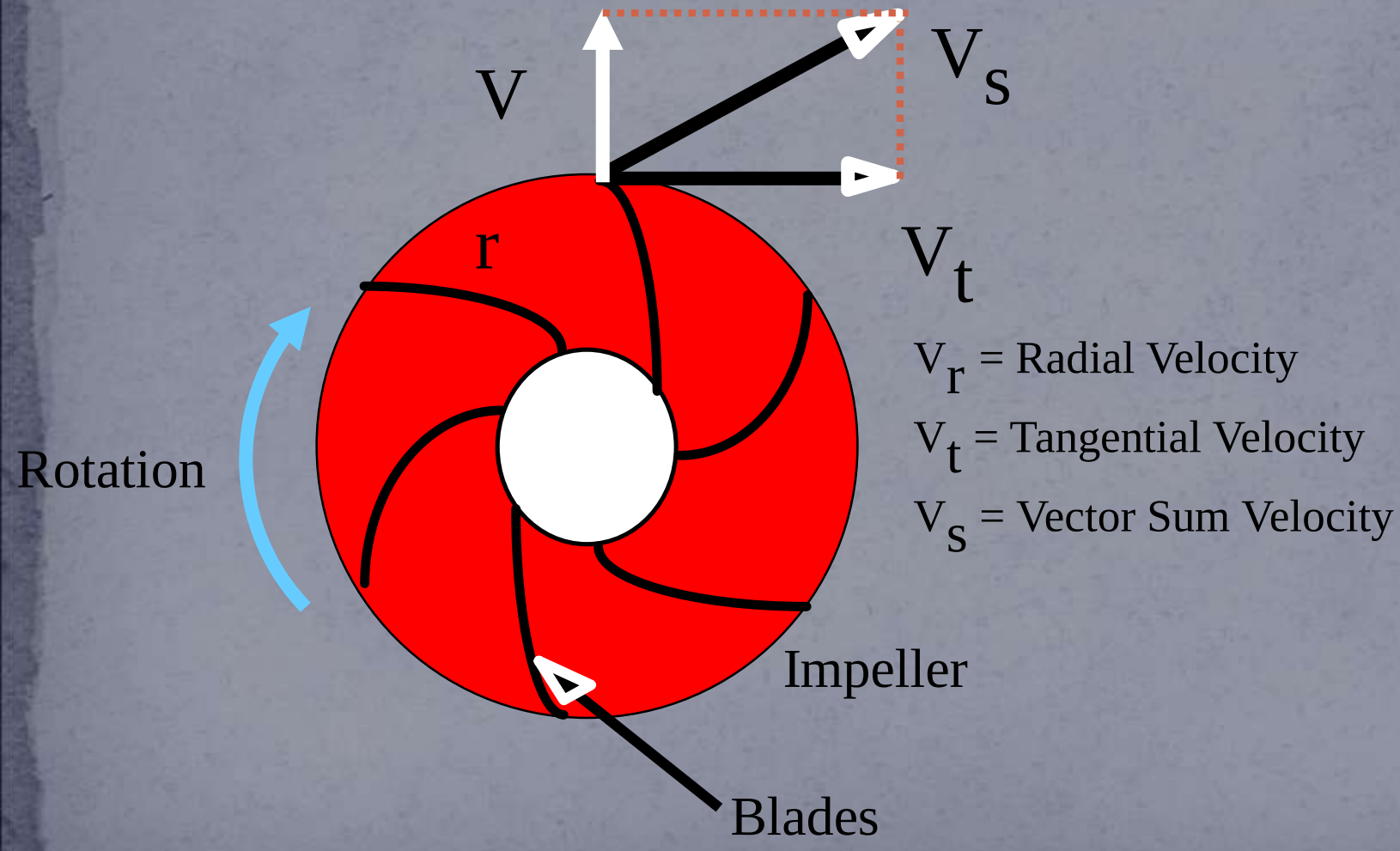

Pressure Side
Downstream Pipe Flange
Driveshaft Flange
Rotating Direction Indicator
Pump Casing
Volute Chamber
Impeller
Suction Side
Upstream Pipe Flange

Full Diameter Impeller



V_r = Radial Velocity

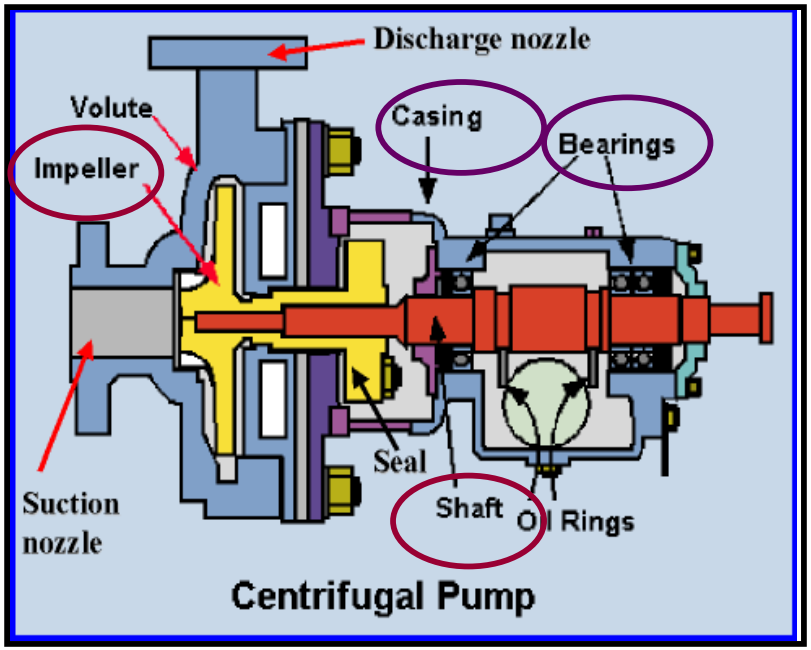
V_t = Tangential Velocity

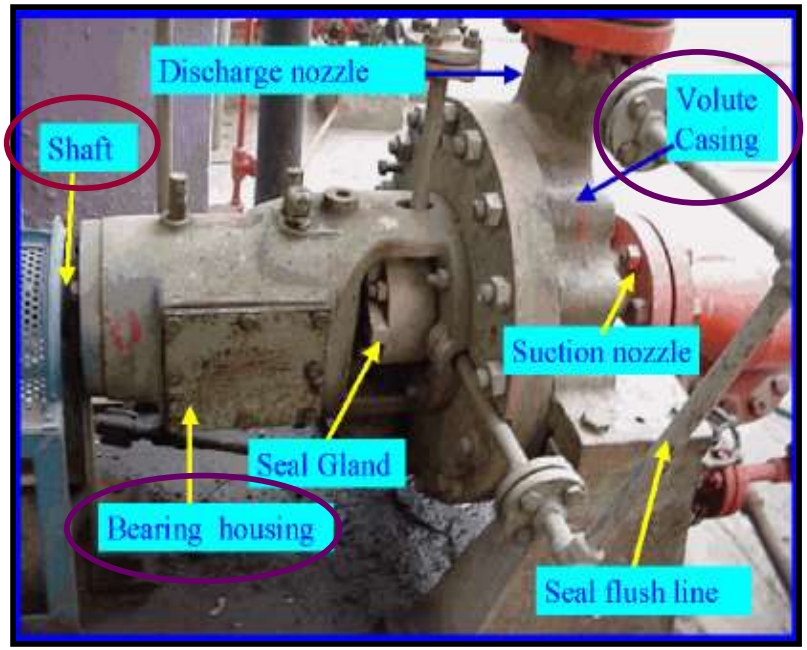
V_s = Vector Sum Velocity

Selection of Pump:

- ✓ The amount of fluid
- ✓ The properties of the fluid
- ✓ Type of power supply
- ✓ Cost and mechanical efficiency of the pump

Rotating and stationary components





Pump shaft power (Ps):

Ps = Hydraulic power Hp / pump efficiency ηPump

Pump Efficiency (ηPump):

ηPump = Hydraulic Power / Pump Shaft Power

- **Pump output/Hydraulic/Water horsepower (Hp) is the liquid horsepower delivered by the pump**

Hydraulic power (Hp):

Hp = Q (m3/s) x Total head, [hd - hs (m)] x ρ (kg/m3) x g (m/s2) / 1000

hd - discharge head
hs – suction head,
ρ - density of the fluid
g – acceleration due to gravity

How to Calculate Pump Performance

- **Pump shaft power (Ps) is actual horsepower delivered to the pump shaft**

  Pump shaft power (Ps):

  Ps = Hydraulic power Hp / pump efficiency ηPump

  Pump Efficiency (ηPump):

  ηPump = Hydraulic Power / Pump Shaft Power

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  hs – suction head,

  ρ - density of the fluid

  g – acceleration due to gravity

MULTISTAGE CENTRIFUGAL PUMP

- A centrifugal pump containing two or more impellers is called a multistage centrifugal pump.
- The impellers may be mounted on the same shaft or on different shafts.
- If we need higher pressure at the outlet we can connect impellers in series.
- If we need a higher flow output we can connect impellers in parallel.
- All energy added to the fluid comes from the power of the electric or other motor force driving the impeller.

Energy usage

The energy usage in a pumping installation is determined by the flow required, the height lifted and the length and friction characteristics of the pipeline. The power required to drive a pump (P_i), is defined simply using SI units by:

$$P_i = \frac{\rho\ g\ H\ Q}{\eta}$$

where:

P_i	is	the input power required (W)
ρ	is	the fluid density (kg/m^3)
g	is	the standard acceleration of gravity (9.80665 m/s^2)
H	is	the energy Head added to the flow (m)
Q	is	the flow rate (m^3/s)
η	is	the efficiency of the pump plant as a decimal

The head added by the pump (H) is a sum of the static lift, the head loss due to friction and any losses due to valves or pipe bends all expressed in metres of fluid. Power is more commonly expressed as kilowatts (10^3 W) or horsepower (multiply kilowatts by 0.746). The value for the pump efficiency η may be stated for the pump itself or as a combined efficiency of the pump and motor system.

The **energy usage** is determined by multiplying the power requirement by the length of time the pump is operating.

Priming

Most centrifugal pumps are not self-priming.

In other words, the pump casing must be filled with liquid before the pump is started, or the pump will not be able to function.

If the pump casing becomes filled with vapors or gases, the pump impeller becomes gas-bound and incapable of pumping.

To ensure that a centrifugal pump remains primed and does not become gas-bound, most centrifugal pumps are located below the level of the source from which the pump is to take its suction.

The same effect can be gained by supplying liquid to the pump suction under pressure supplied by another pump placed in the suction line.

Energy Efficiency Opportunities

1. Selecting the right pump
2. Controlling the flow rate by speed variation
3. Pumps in parallel to meet varying demand
4. Eliminating flow control valve
5. Eliminating by-pass control
6. Start/stop control of pump
7. Impeller trimming

Advantages of centrifugal Pump

1. Cost of centrifugal pump is less.
2. Very efficient and Efficiency is high
3. Produce smooth and even flow.
4. Reliable with good service life.
5. The discharge is continuous, smooth and high.
6. It can handle large quantity of fluid.
7. It can be used for lifting highly discharge through smaller heads.
8. Cost of centrifugal pump is less as compared to reciprocating pump.
9. Centrifugal pump runs at high speed, they can be coupled to electric motor.
10. Centrifugal pump needs smaller floor area and installation cost and maintenance cost are low.

Advantages

- Simple in construction and cheap
- Handle liquid with large amounts of solids
- No metal to metal fits
- No valves involved in pump operation
- Maintenance costs are lower

Disadvantages

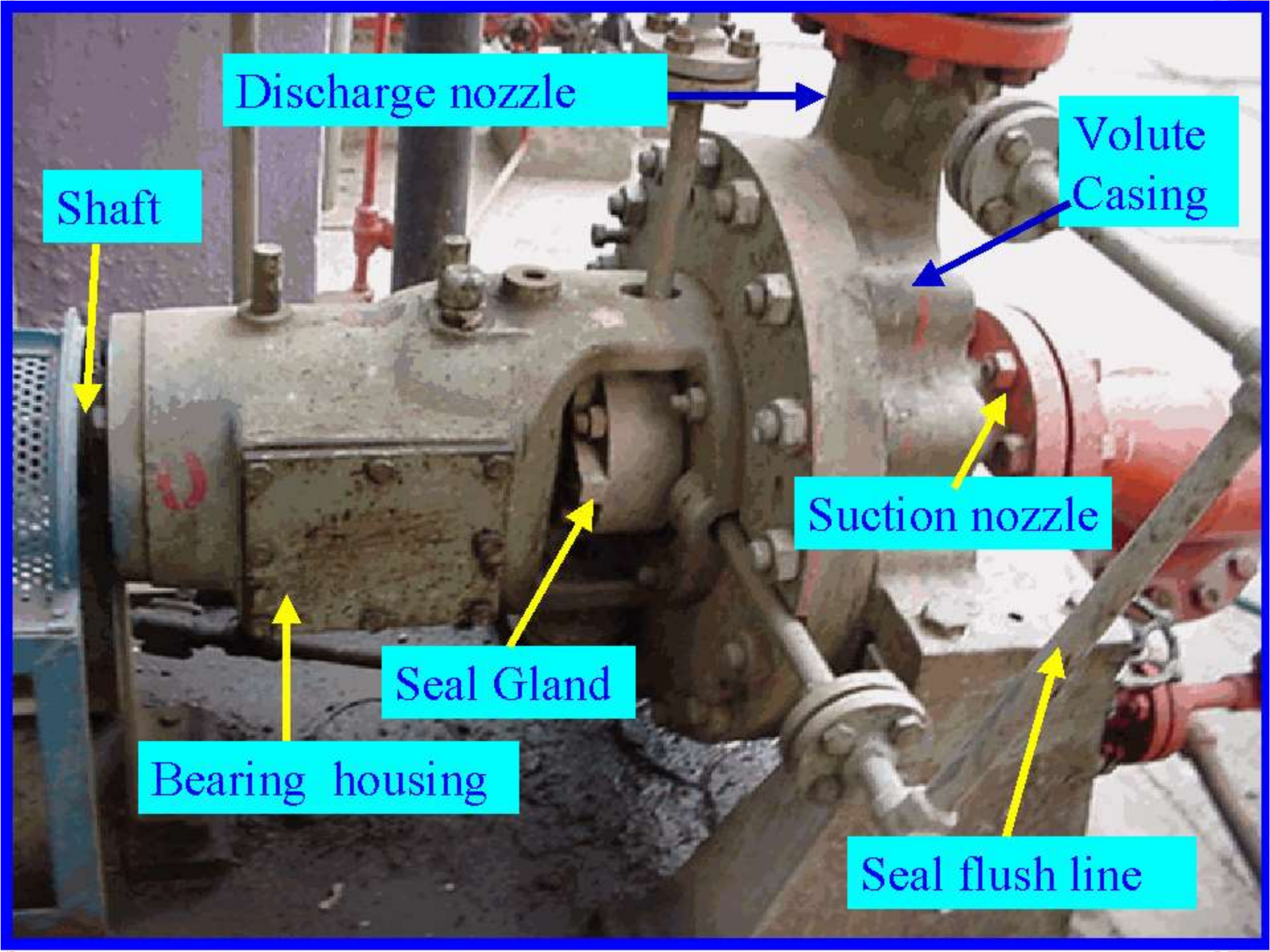
- Cannot handle highly viscous fluids efficiently
- Cannot be operated at high heads
- Maximum efficiency holds over a narrow range of conditions

Disadvantages

1. Loss of priming easily
2. Efficiency depends upon operating design head & speed.
3. Cannot be operated at high heads.
4. Maximum efficiency holds over a narrow range of conditions

APPLICATION

- Lifting high viscous liquid.
- Paper and pulp industry.
- Muddy and sewage water.
- Oil industry and oil engine.
- Sugar molasses industry.


Discharge nozzle
Volute Casing
Shaft
Suction nozzle
Seal Gland
Bearing housing
Seal flush line

THANK YOU