PRESENTATION OUTLINE

- Pump Terminology
- Pump Classification:
  - Reciprocating Pumps
  - Rotary Pumps
  - Centrifugal Pumps
- Pumping Problems
- Power and Efficiency Calculations
- Pump Selection

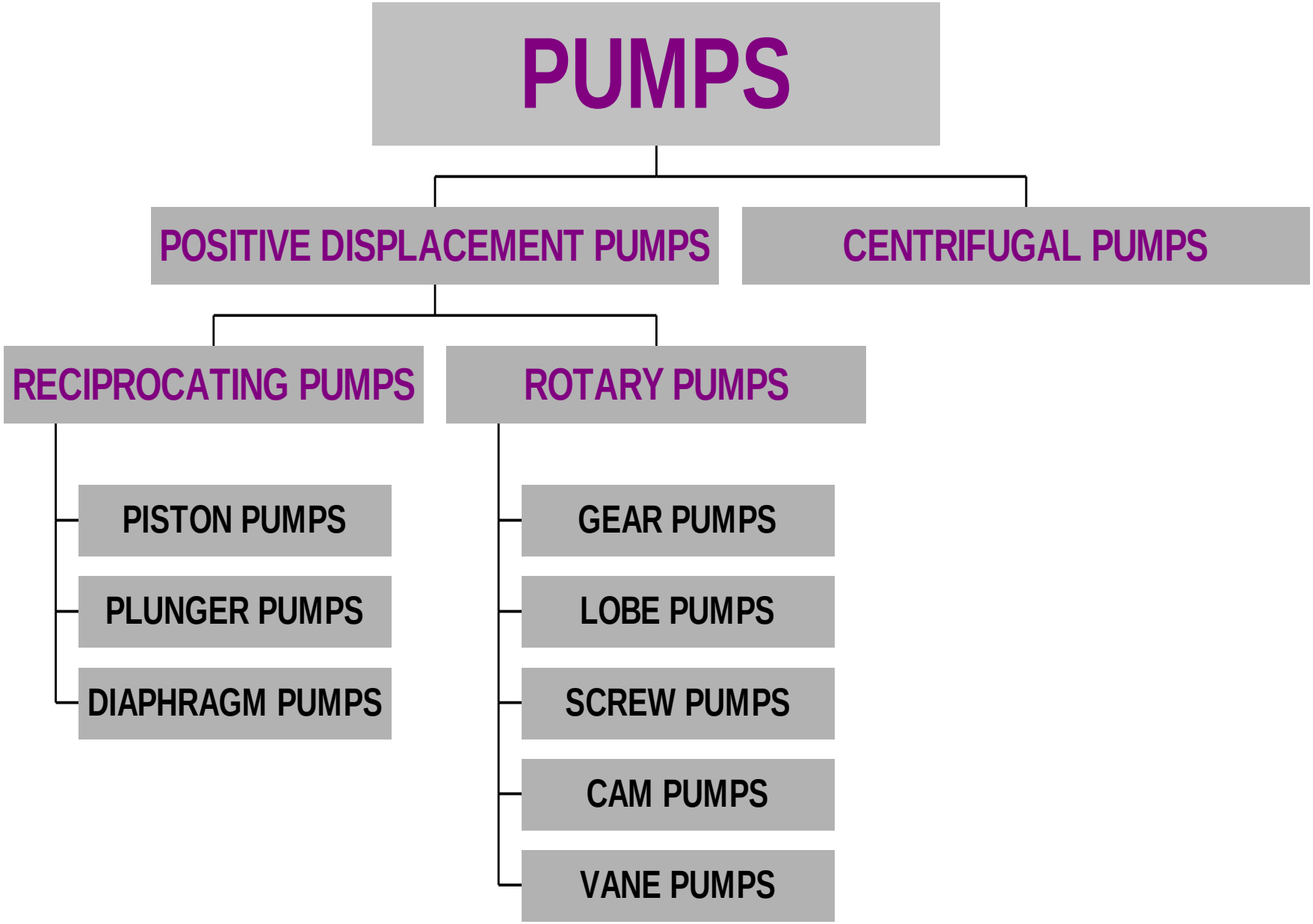
PUMP TERMINOLOGY

- **Pumping,** the addition of energy to a fluid
- Pumping action creates a partial vacuum while atmospheric pressure forces liquid up.
- **Pump performance**, specified in terms of Q and H:

$$H = Q/t = \left(\frac{P_{d,g} - P_{s,g}}{\gamma}\right) + \left(\frac{V_d^{\,2}}{2g} - \frac{V_s^{\,2}}{2g}\right) + (Z_d - Z_s)$$

- **Displacement**, the discharge of a fluid from a vessel

- **Centrifugal Force**, used to produce kinetic energy


PUMPS
POSITIVE DISPLACEMENT PUMPS
CENTRIFUGAL PUMPS
RECIPROCATING PUMPS
ROTARY PUMPS
PISTON PUMPS
PLUNGER PUMPS
DIAPHRAGM PUMPS
GEAR PUMPS
LOBE PUMPS
SCREW PUMPS
CAM PUMPS
VANE PUMPS

RECIPROCATING PUMPS

- Based on two stroke principles:

  √ High pressure, high efficiency

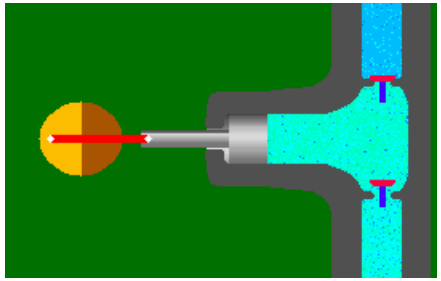
  √ Self-priming

  X Small quantity, vibration, physical dimension, uneven flow

- Used mainly for handling slurries in plant processes and pipeline applications

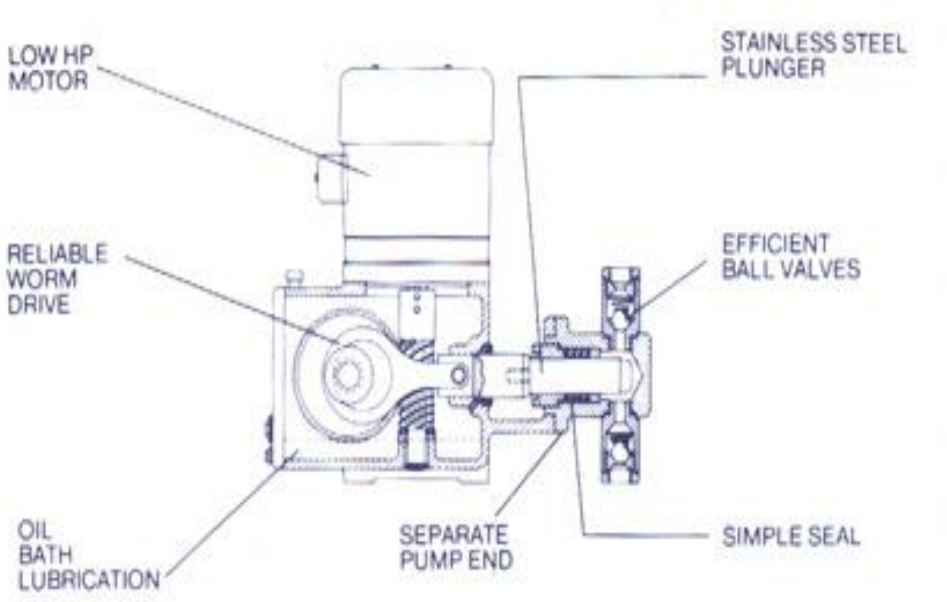
- POSITIVE DISPLACEMENT PUMPS
  - RECIPROCATING PUMPS
    - **PISTON PUMPS**
    - PLUNGER PUMPS
    - DIAPHRAGM PUMPS

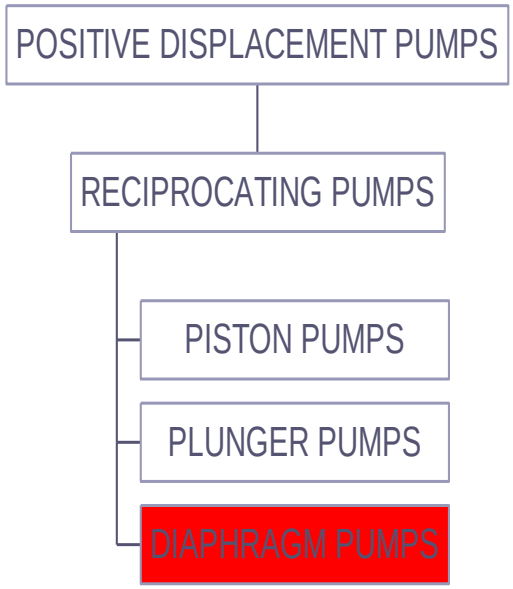
- Two valves and one stuffing box
- A rotating mechanism for the reciprocating piston
- Uses suction to raise liquid into the chamber.

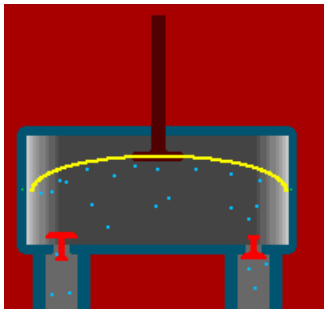


- POSITIVE DISPLACEMENT PUMPS
  - RECIPROCATING PUMPS
    - PISTON PUMPS
    - PLUNGER PUMPS
    - DIAPHRAGM PUMPS

- Two ball check valves on each side
- Low pressure on the upward part, high pressure on the downward part







- Rod is moved to push and pull the diaphragm.
- Can be used to make artificial hearts.

ROTARY PUMPS

- Positive displacement type

 High pressure, high efficiency

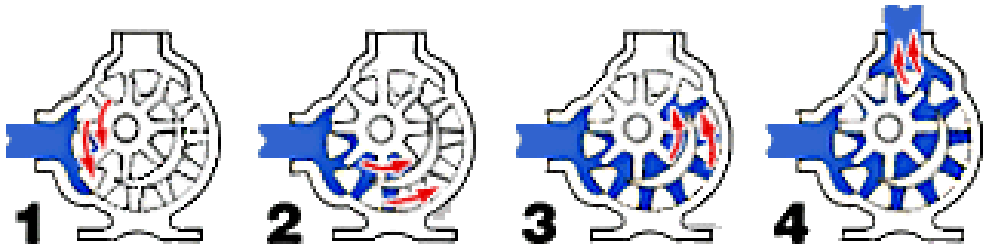
 Liquids must be free of solids

 Handle viscous fluids

- Used mainly in, oil burners, soaps and cosmetics, sugars, syrup, and molasses, dyes, ink, bleaches, vegetable and mineral oils

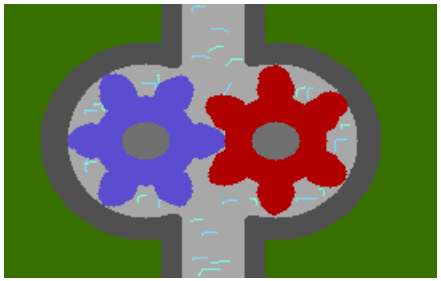
- ROTARY PUMPS
  - GEAR PUMPS
  - LOBE PUMPS
  - SCREW PUMPS
  - CAM PUMPS
  - VANE PUMPS

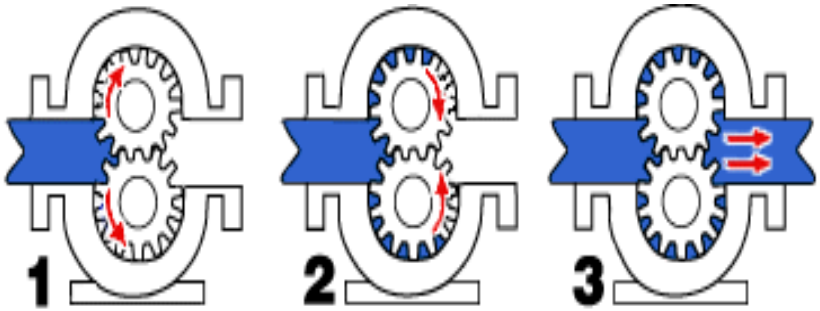
- Gears create voids as they come out of mesh and liquid flows into the cavities
- As the gears come back into mesh, the volume is reduced and the liquid is forced out of the discharge port



- ROTARY PUMPS
  - GEAR PUMPS
  - LOBE PUMPS
  - SCREW PUMPS
  - CAM PUMPS
  - VANE PUMPS

- As the teeth come out of mesh, liquid flows into the pump and is carried between the teeth and the casing to the discharge side of the pump
- The teeth come back into mesh and the liquid is forced out the discharge port



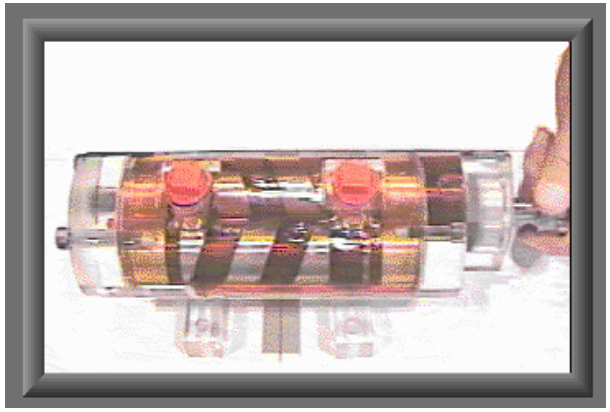


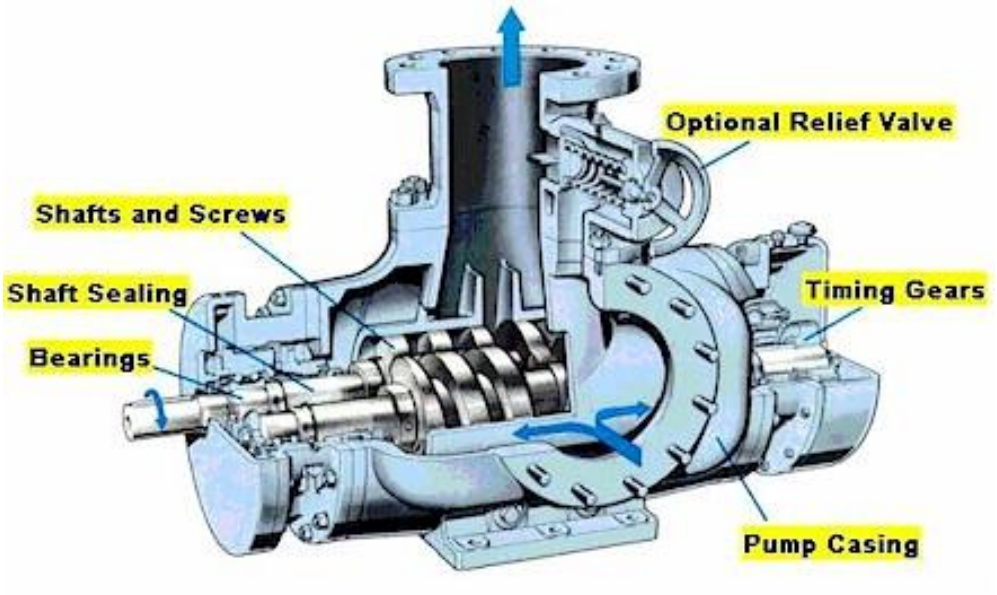
- ROTARY PUMPS
  - GEAR PUMPS
  - **LOBE PUMPS**
  - SCREW PUMPS
  - CAM PUMPS
  - VANE PUMPS

- Fluid is carried between the rotor teeth and the pumping chamber
- The rotor surfaces create continuous sealing
- Rotors include bi-wing, tri-lobe, and multi-lobe configurations

- ROTARY PUMPS
  - GEAR PUMPS
  - LOBE PUMPS
  - SCREW PUMPS
  - CAM PUMPS
  - VANE PUMPS

- Screw pumps carry fluid in the spaces between the screw threads.
- The fluid is displaced axially as the screws mesh.



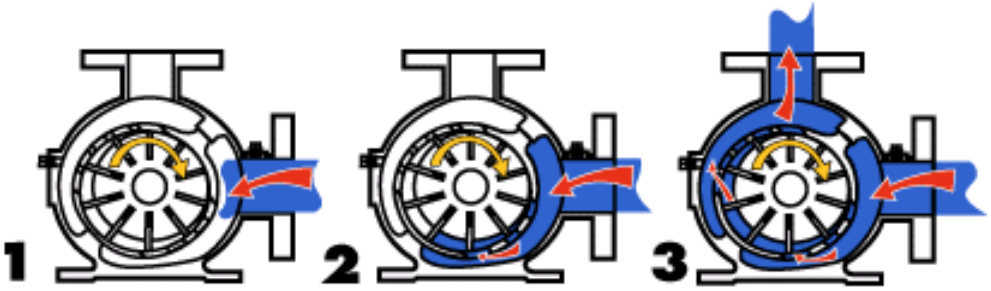


- ROTARY PUMPS
  - GEAR PUMPS
  - LOBE PUMPS
  - SCREW PUMPS
  - **CAM PUMPS**
  - VANE PUMPS

- Piston slide arm moves around inside a slot in the casing.
- An eccentric cam rotates the circular plunger (shown in gray) around the edge of the casing, fluid is swirled around the edge to the outlet port.
- It is not in use now and is mainly of historical curiosity.

- ROTARY PUMPS
  - GEAR PUMPS
  - LOBE PUMPS
  - SCREW PUMPS
  - CAM PUMPS
  - VANE PUMPS

- The vanes are in slots in the rotor.
- Rotor spins, centrifugal force pushes the vanes out to touch the casing, where they trap and propel fluid.



CENTRIFUGAL PUMPS

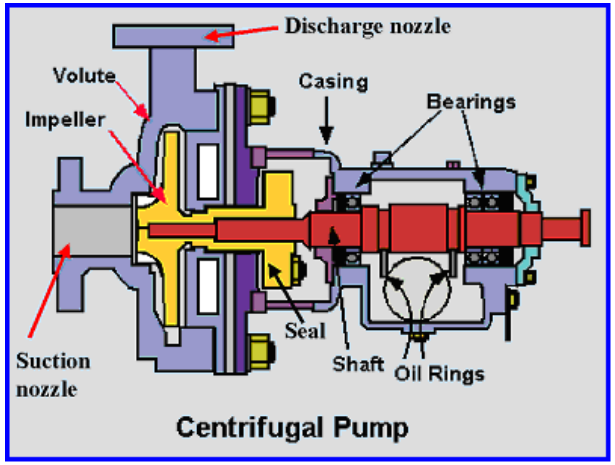
- WHAT IS CENTRIFUGAL PUMP?
- WORKING MECHANISM OF A CENTRIFUGAL PUMP
- ADVANTEGAES AND DISADVANTAGES OF CENTRIFUGAL PUMPS

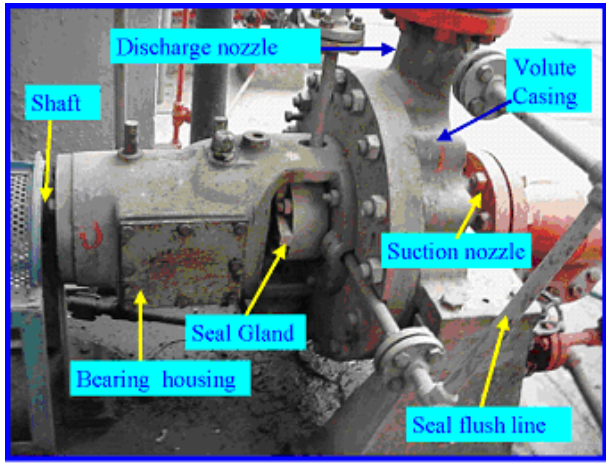
WHAT IS CENTRIFUGAL PUMP?

- 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

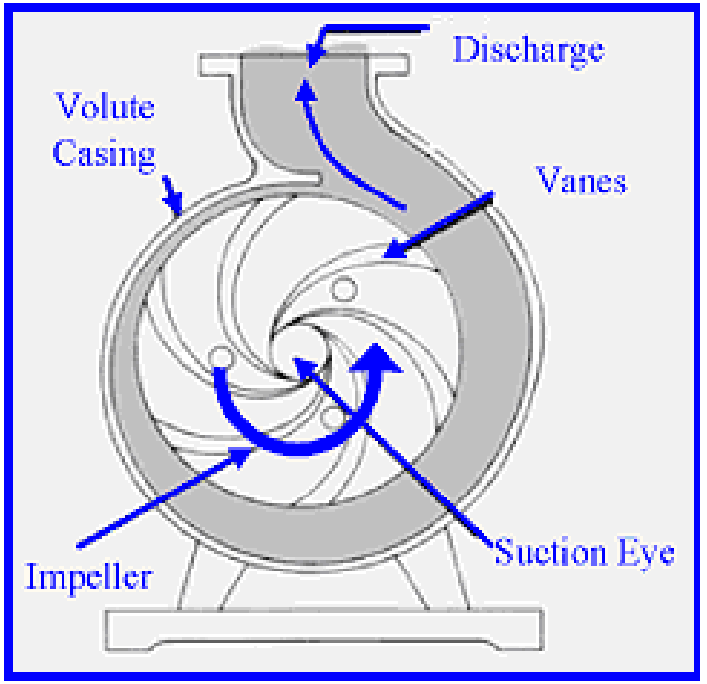
  2. Rotating components, impeller and shaft
- Classified into three categories ; Radial Flow, Mixed Flow, Axial Flow





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



Liquid flow path inside a centrifugal pump

ADVANTAGES OF CENTRIGUGAL PUMPS

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 OF CENTRIFUGAL PUMPS

Disadvantages

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

PUMPING PROBLEMS

Cavitation

Reduces the pump capacity

Causes metal removal

reduced flow

loss in efficiency

and noise

To avoid cavitation **~~NPSH~~**

$$NPSH = \frac{g_c}{g}\left(\frac{P_a - P_v}{\rho} - h_{fs}\right) - Z_a$$

POWER AND EFFICIENCY CALCULATIONS

- **<u>The power supplied to the pump</u>:**

$$P_b = \frac{m \ \Delta H}{\eta} \qquad \text{.....(1)}$$

Where m=mass flow rate, kg/s

ΔH= total discharge head, N.m/kg

η=efficiency

...

- **The power delivered to the fluid:**

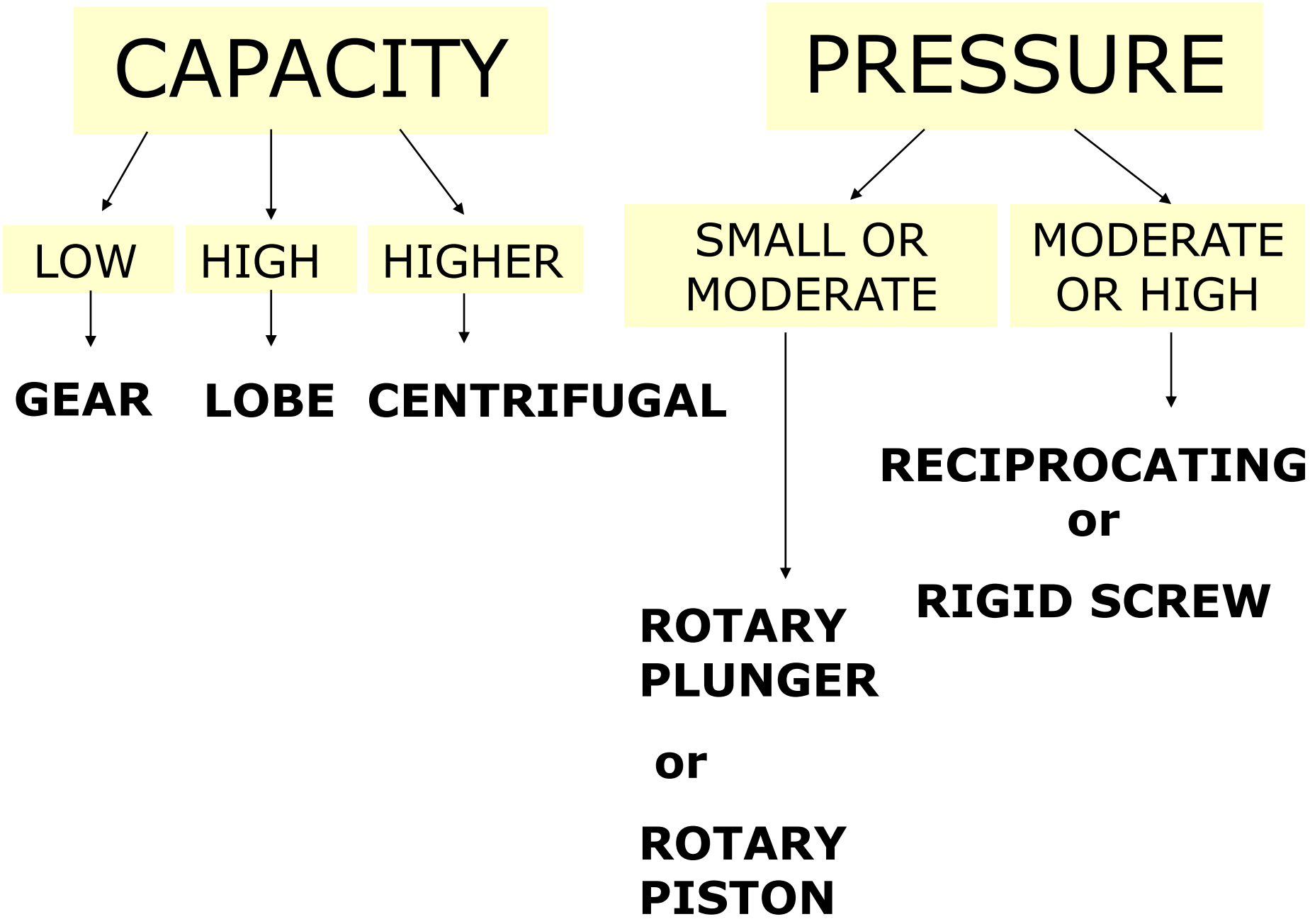
$$P_f = m\Delta H \qquad \text{.....(2)}$$

- From equations (1) and (2) **efficiency**:

$$\eta = \frac{P_f}{P_b}$$

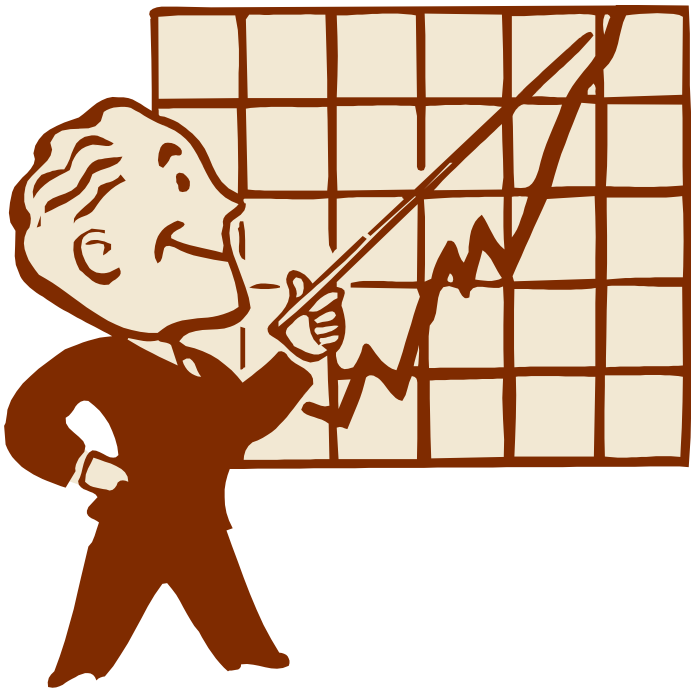
PUMP SELECTION

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


CAPACITY
PRESSURE
LOW
HIGH
HIGHER
SMALL OR MODERATE
MODERATE OR HIGH
GEAR
LOBE
CENTRIFUGAL
ROTARY PLUNGER
or
ROTARY PISTON
RECIPROCATING
or
RIGID SCREW

REFERENCES

1. http://en.wikipedia.org/wiki/Pump
2. www.cheresources.com
3. www.pumpworld.com/contents.htm
4. www.rpi.edu./dept/chem-eng/ Biotech-Environ/PUMPS/intro.html



Thanks