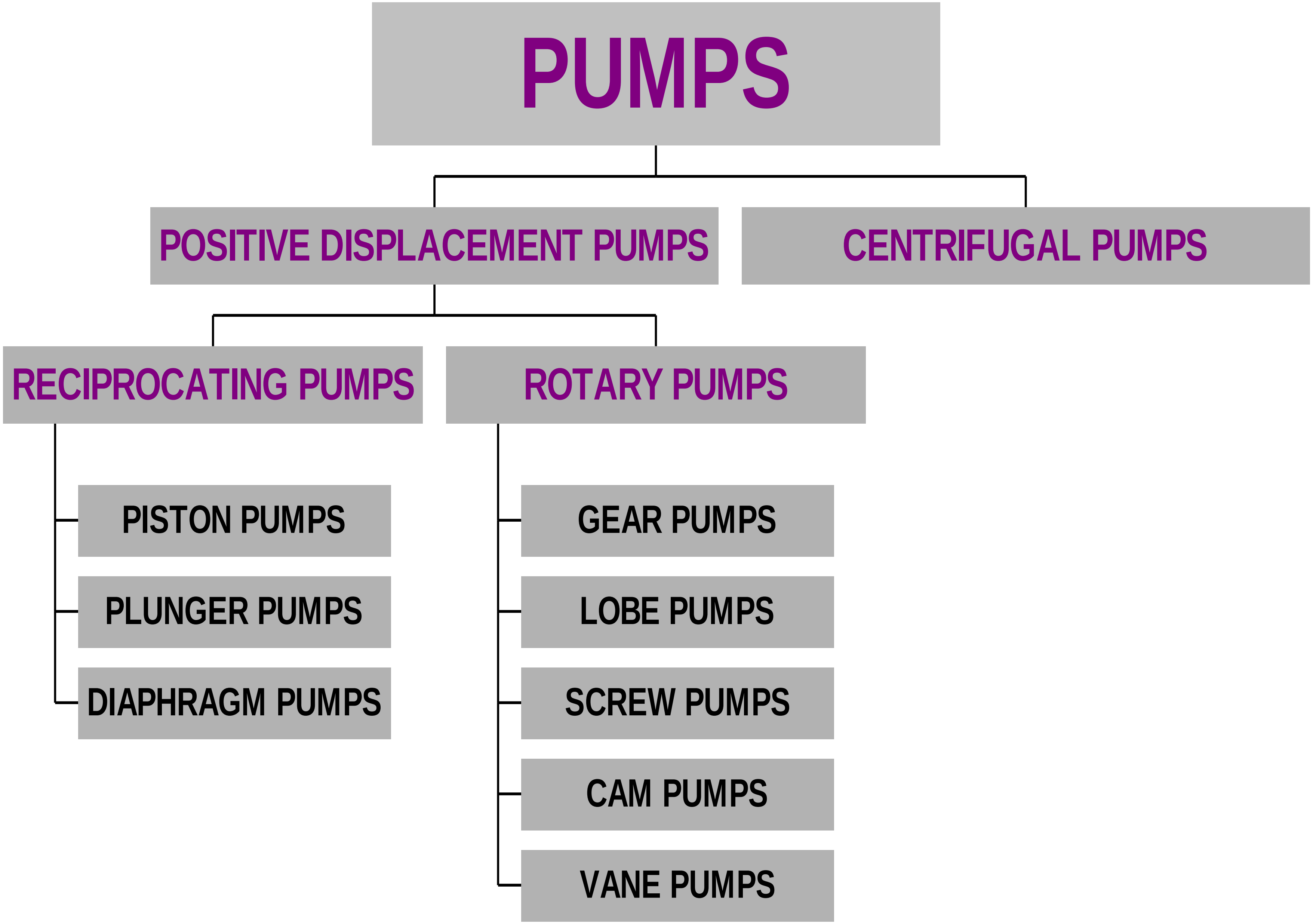
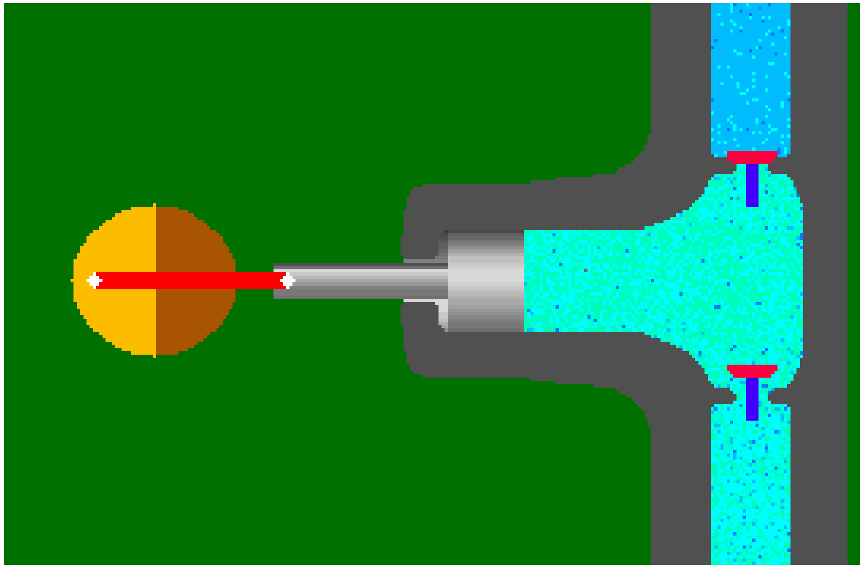

PUMPS
POSITIVE DISPLACEMENT PUMPS
CENTRIFUGAL PUMPS
RECIPROCATING PUMPS
ROTARY PUMPS
PISTON PUMPS
PLUNGER PUMPS
DIAPHRAGM PUMPS
GEAR PUMPS
LOBE PUMPS
SCREW PUMPS
CAM PUMPS
VANE PUMPS

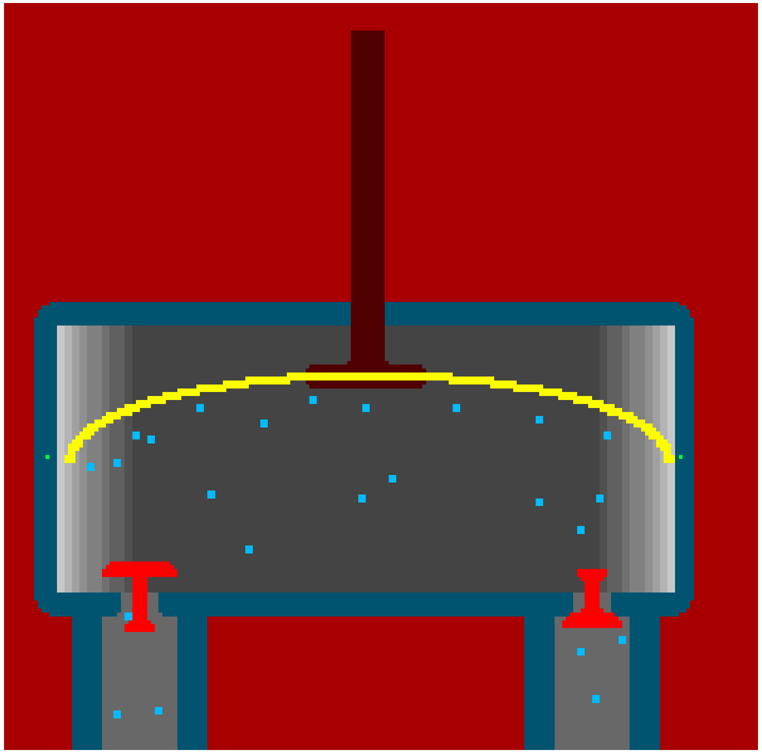
Piston Pump

- Two valves and one stuffing box
- A rotating mechanism for the reciprocating piston



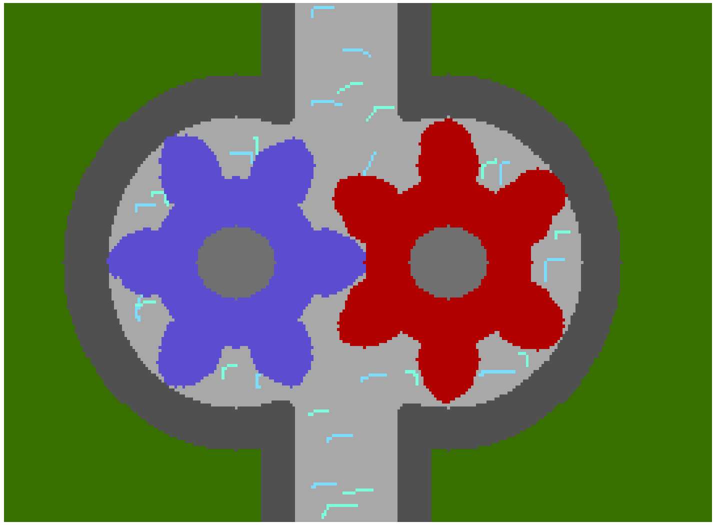
Diaphragm Pump

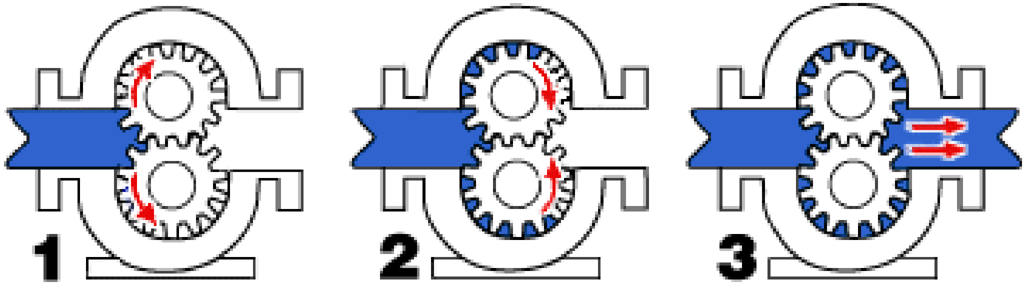
- Rod is moved to push and pull the diaphragm.
- Can be used to make artificial hearts.



Gear Pump

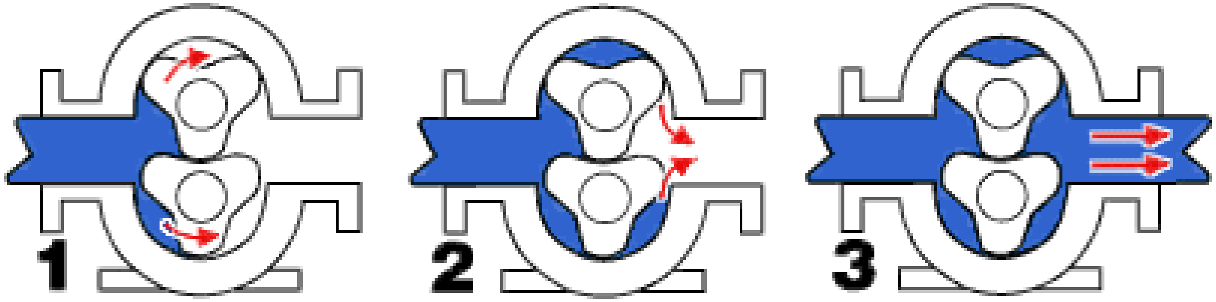
- Liquid flows into the pump and is carried between the teeth and the casing to the discharge side of the pump
- The teeth come back into mesh and the liquid is forced out the discharge port





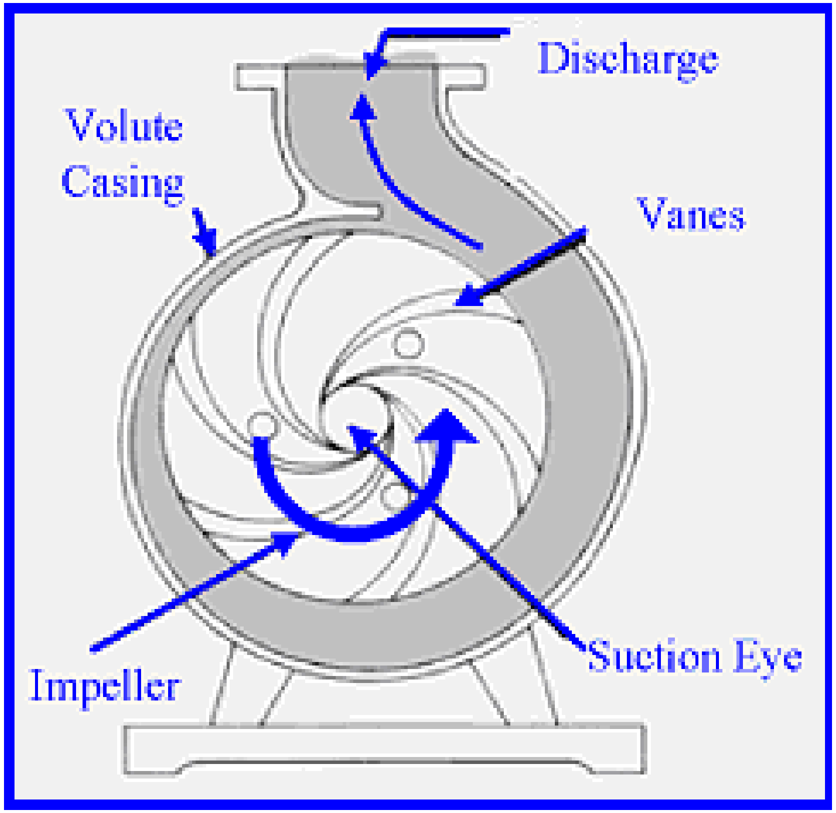
Lobe Pump

- Fluid is carried between the rotor teeth and the pumping chamber
- The rotor surfaces create continuous sealing



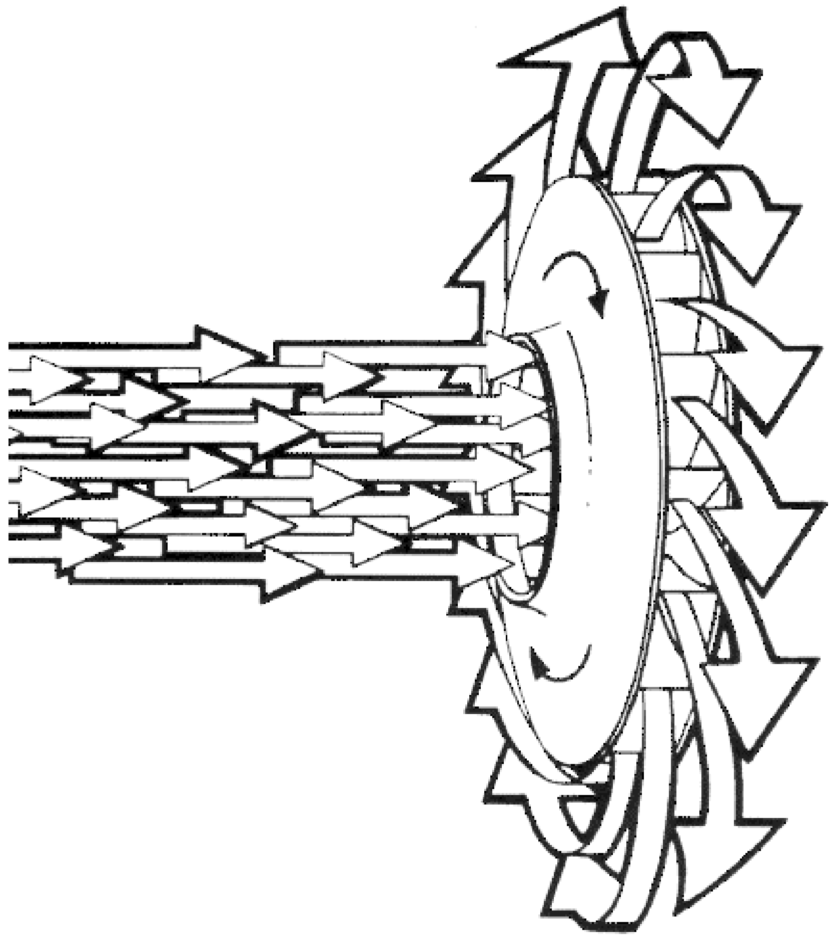
Centrifugal Pump

- 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

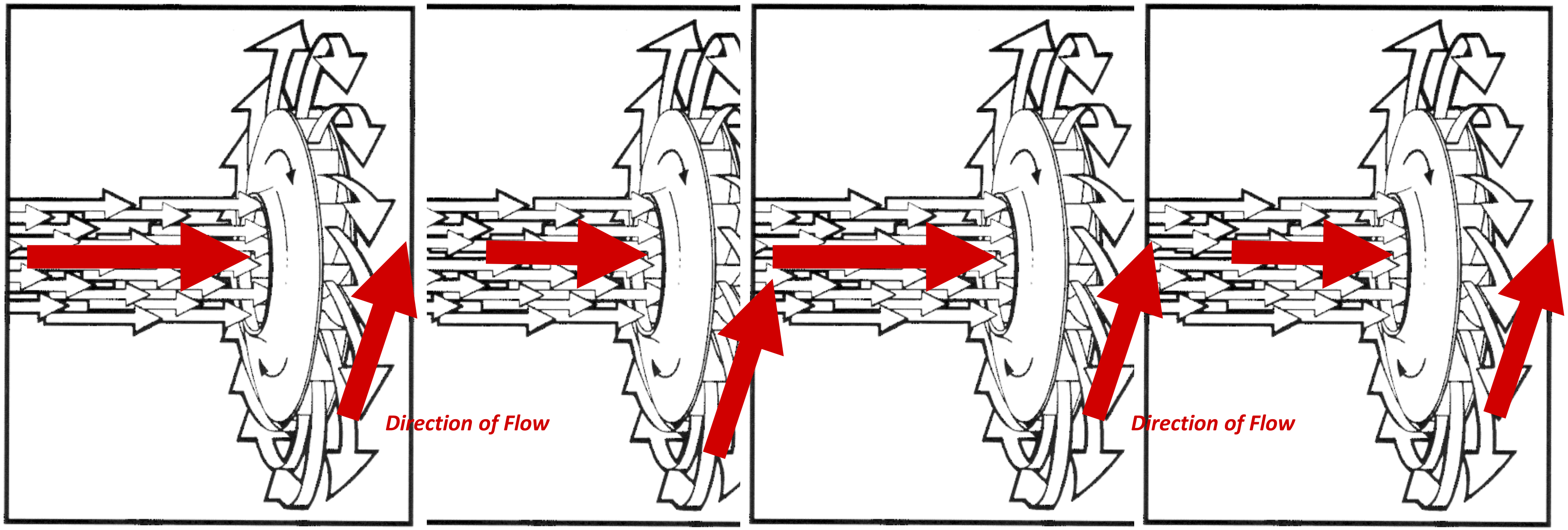


Centrifugal Pump

Liquid directed into the center of the rotating impeller is picked up by the impeller's vanes and accelerated to a higher velocity by the rotation of the impeller and discharged by centrifugal force into the case (diffuser).

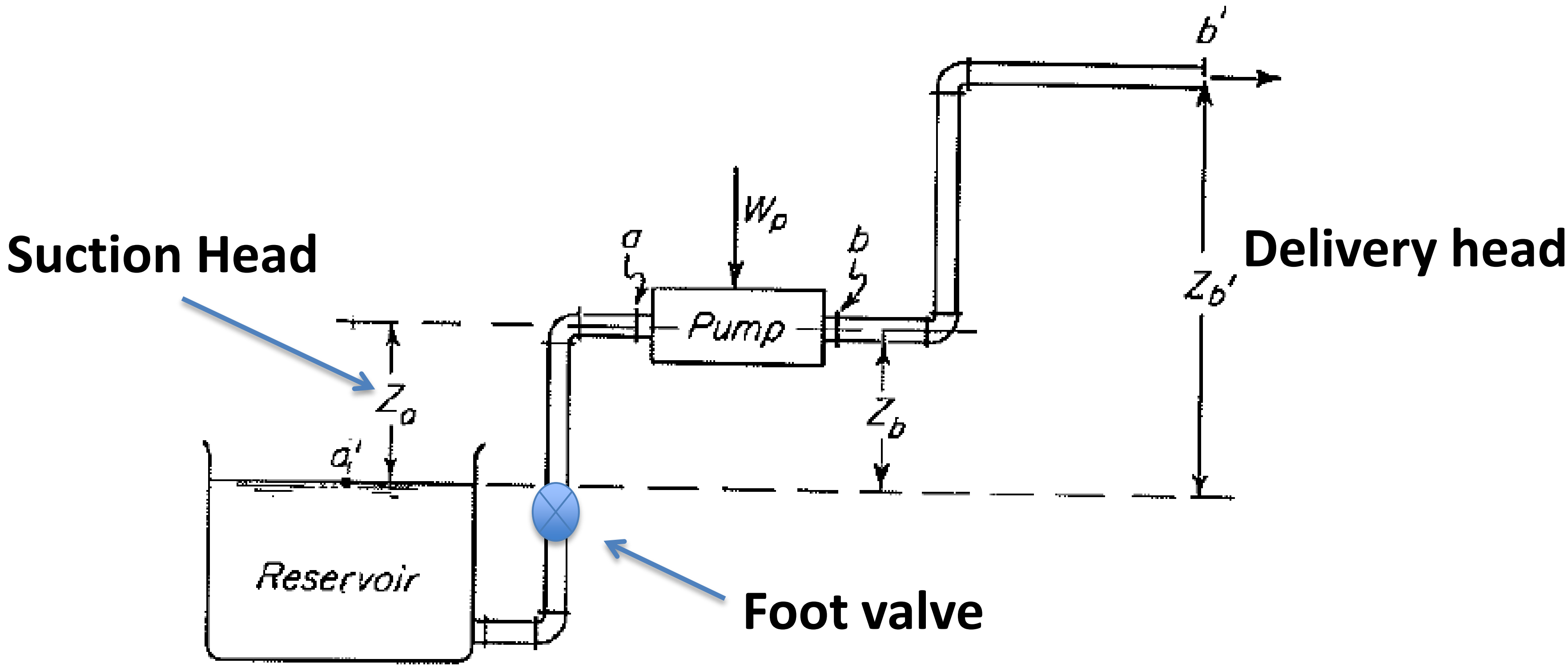


Multiple Impellers in Series



- Placing impellers in series increases the amount of head produced
- The head produced = No. of impellers x head of one impeller

Centrifugal Pump System



Net Positive Suction Head (NPSH)

NPSH is defined as difference between pump inlet pressure to the vapour pressure of the liquid at the pump inlet temperature and pressure condition

$$NPSH = \frac{1}{g}\left(\frac{P_r - P_v}{\rho} - h_{lt}\right) - Z$$

Where P_r = Reservoir pressure

P_v = Vapour pressure of liquid at pump inlet condition

Z= height of the pump above the reservoir level

h_{lt} = Total losses (Major + Minor)

The velocity head at the pump inlet , $\frac{\alpha V^2}{2}$, can be subtracted from the above result to get a more theoretically correct value of NPSH

Net Positive Suction Head (NPSH)

- **NPSH Available ($NPSH_A$): The absolute pressure at the suction port of the pump.**

- **NPSH Required ($NPSH_R$): The minimum pressure required at the suction port of the pump to avoid cavitation.**

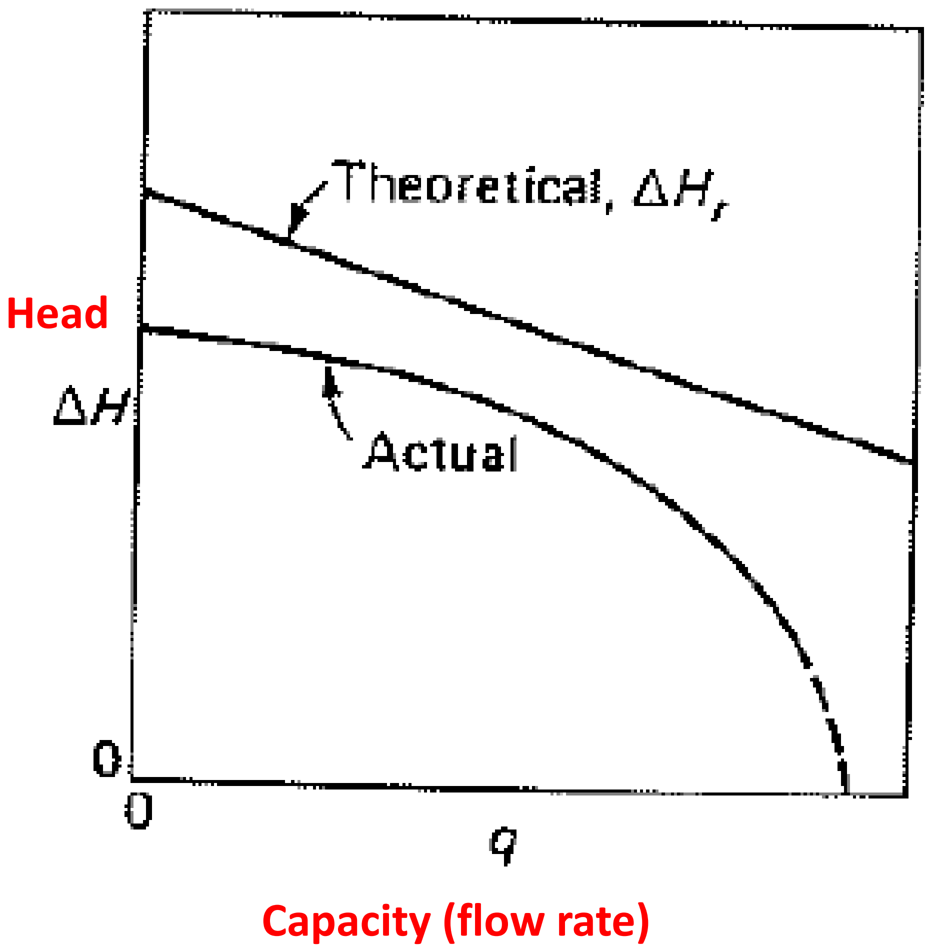
- **$NPSH_A$ is a function of the system and must be calculated, whereas $NPSH_R$ is a function of the pump and must be provided by the pump manufacturer.**

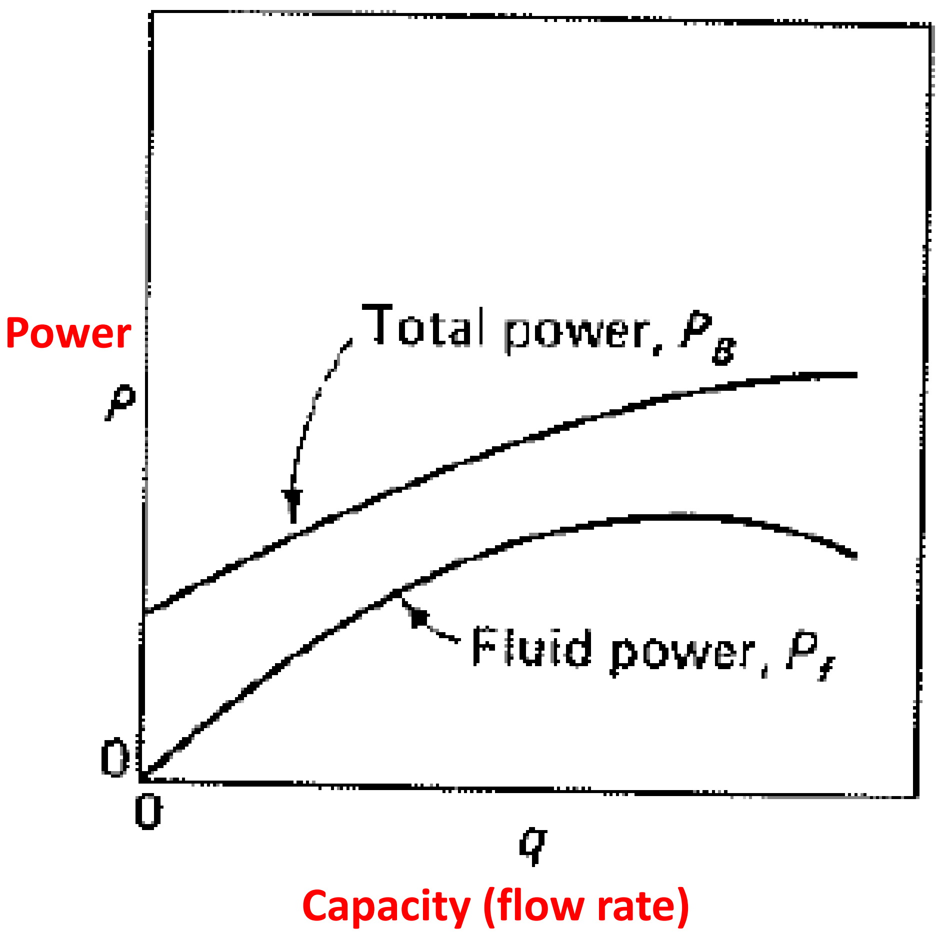
- **<u>$NPSH_A$ MUST be greater than $NPSH_R$</u> for the pump system to operate without cavitation.**

Cavitation

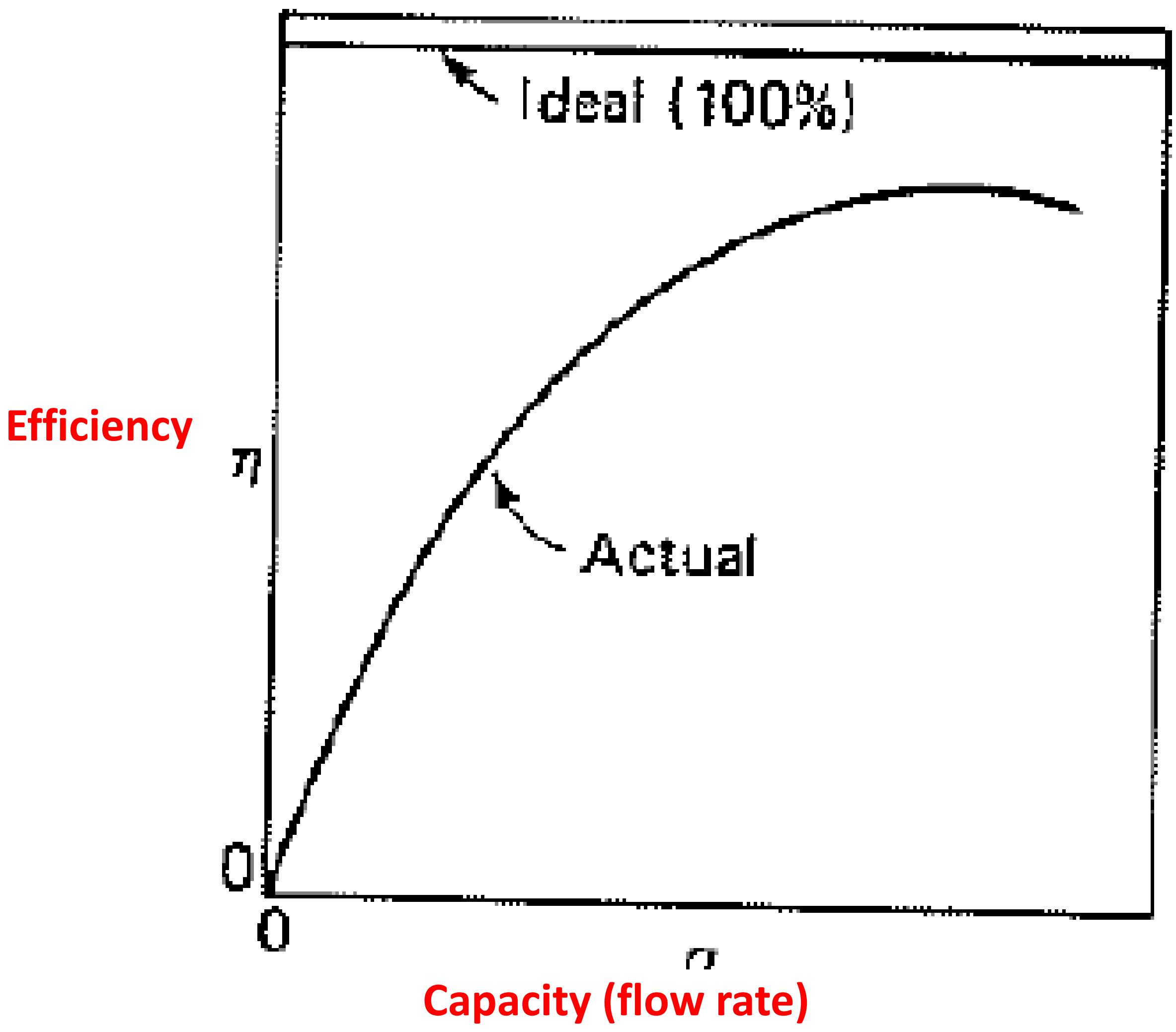
- Formation and breakage (death) of the bubbles are called cavitation
- If suction pressure of the pump is slightly higher than he vapour pressure of the liquid at the pump inlet condition some liquid may get flash and cavitation in the pump occurs
- Cavitation reduces the pump capacity and causes severe erosion
- If suction pressure is less than the vapour pressure of the liquid then the vaporization occurs in the suction line and no liquid will be drawn into the pump
- To avoid cavitation the pressure at the pump inlet must exceed the vapour pressure by a value equal to NPSH

Centrifugal Pump Characteristic Curve





Centrifugal Pump Characteristic Curve



Affinity Law

$$Q \mu\ n \qquad Q \mu D^3$$

$$H \mu\ n^2 \qquad H \mu D^2$$

$$P \mu\ n^3 \qquad P \mu D^5$$

Where:

n **= rotation (impeller rpm)**

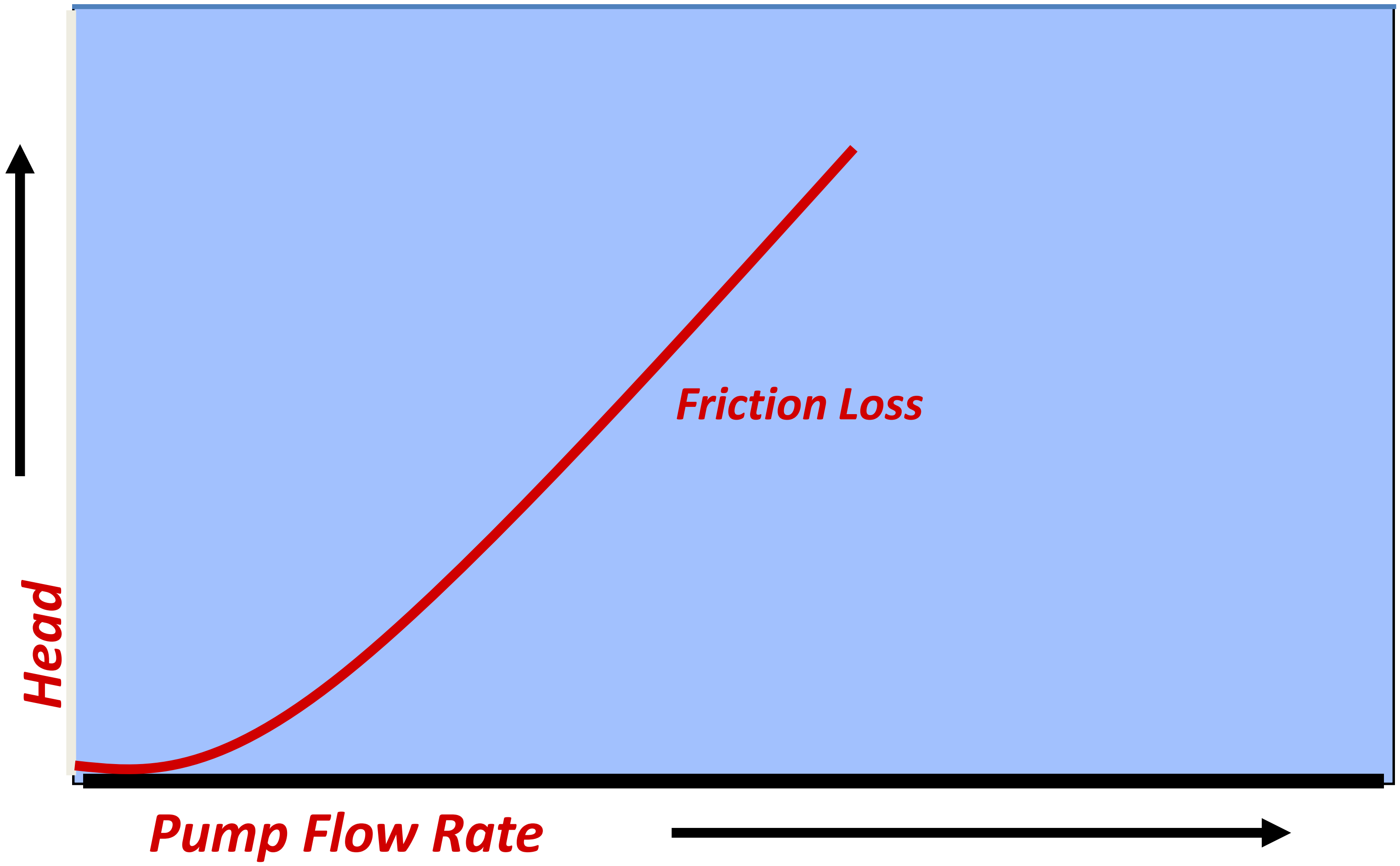
D **= Diameter of impeller**

When both rpm and diameter is changing

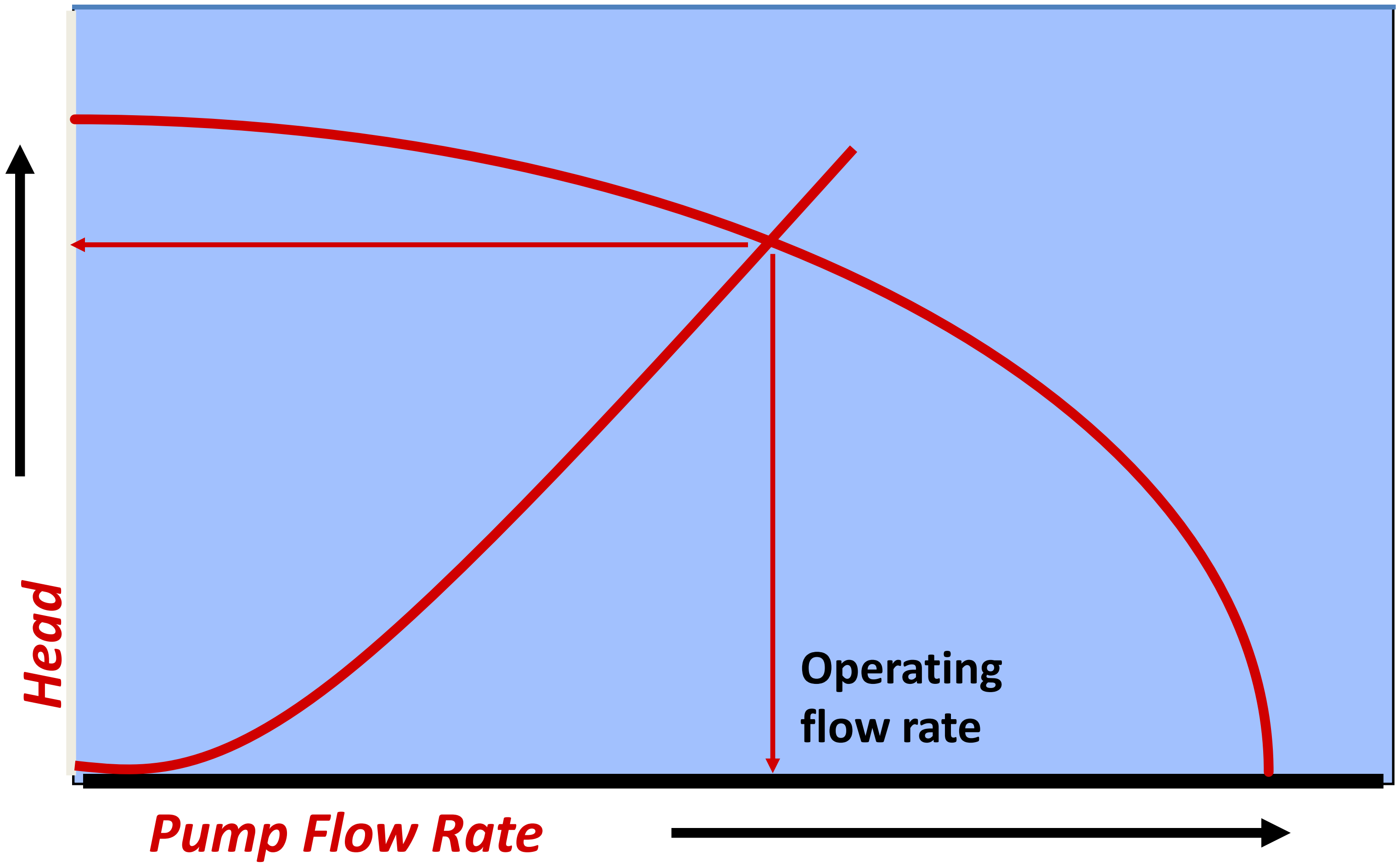
$$\frac{Q_1}{n_1 D_1^3} = \frac{Q_2}{n_2 D_2^3} \quad ; \quad \frac{H_1}{n_1^2 D_1^2} = \frac{H_2}{n_2^2 D_2^2} \quad ; \quad \frac{P_1}{n_1^3 D_1^5} = \frac{P_2}{n_2^3 D_2^5}$$

System Performance Curve

- **The friction loss is mapped**
- **The amount of friction loss varies with flow rate**



The point on the system curve that intersects the pump curve is known as the <u>operating point</u>.



Parameter	Centrifugal Pumps	Reciprocating Pumps	Rotary Pumps
Optimum Flow and Pressure Applications	Medium/High Capacity, Low/Medium Pressure	Low Capacity, High Pressure	Low/Medium Capacity, Low/Medium Pressure
Maximum Flow Rate	100,000+ GPM	10,000+ GPM	10,000+ GPM
Maximum Pressure	6,000+ PSI	100,000+ PSI	4,000+ PSI
Smooth or Pulsating Flow	Smooth	Pulsating	Smooth
Variable or Constant Flow	Variable	Constant	Constant
Space Considerations	Requires Less Space	Requires More Space	Requires Less Space
Costs	Lower Initial Lower Maintenance Higher Power	Higher Initial Higher Maintenance Lower Power	Lower Initial Lower Maintenance Lower Power
Fluid Handling	Suitable for a wide range including clean, clear, non-abrasive fluids to fluids with abrasive, high-solid content. Not suitable for high viscosity fluids	Suitable for clean, clear, non-abrasive fluids. Specially-fitted pumps suitable for abrasive-slurry service. Suitable for high viscosity fluids	Requires clean, clear, non-abrasive fluid due to close tolerances Optimum performance with high viscosity fluids