APPLIED HYDRAULICS

CHPATER 11:

CAVITATION, PUMPS AND TURBINES

Cavitation, Pumps and Turbines

- Turbomachines
- Pumps and turbines
- Use of turbine
- Use of pumps
- Axial pumps
- Radial pumps
- Mixed flow pumps
- Multi stage pumps
- Cavitation in Pumps

Cavitation, Pumps and Turbines

Turbomachines

- Turbomachines are mechanical devices that either extract energy from a fluid (turbine) or add energy to a fluid (pump) as a result of dynamic interactions between the device and the fluid.
- The fluid used can be either a gas or a liquid.
- The basic operating principles are the same whether the fluid is a liquid or a gas.
- Cavitation may be an important design consideration when liquids are involved if the pressure at any point within the flow is reduced to vapor pressure.

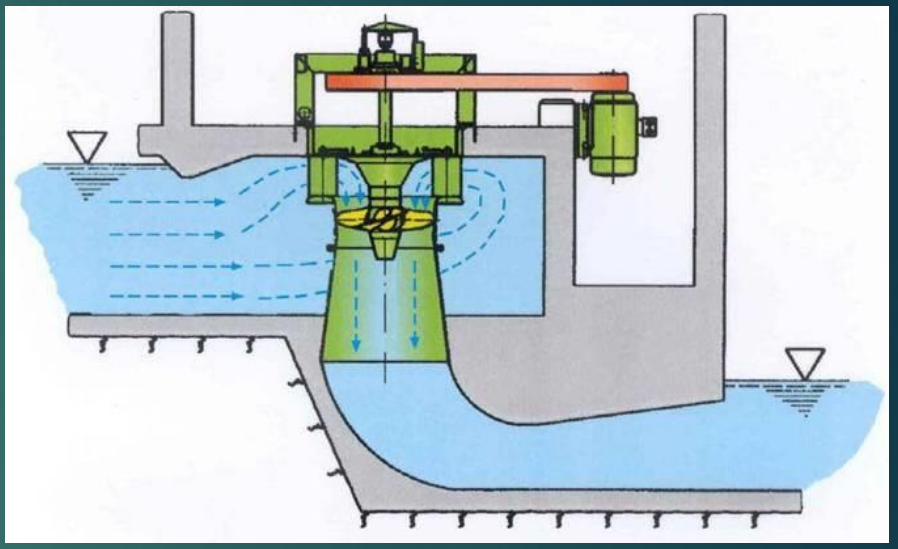
Classification of Turbomachines

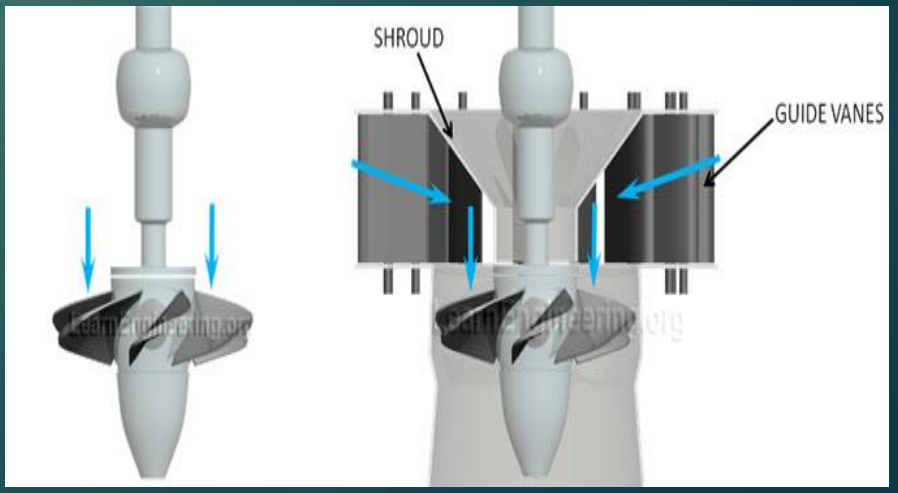
- Turbomachines are also categorized according to the type of flow.
- When the flow is parallel to the axis of rotation, they are called axial flow machines.
- When flow is perpendicular to the axis of rotation, they are referred to as radial (or centrifugal) flow machines.
- There is also a third category, called mixed flow machines, where both radial and axial flow velocity components are present.

Cavitation, Pumps and Turbines

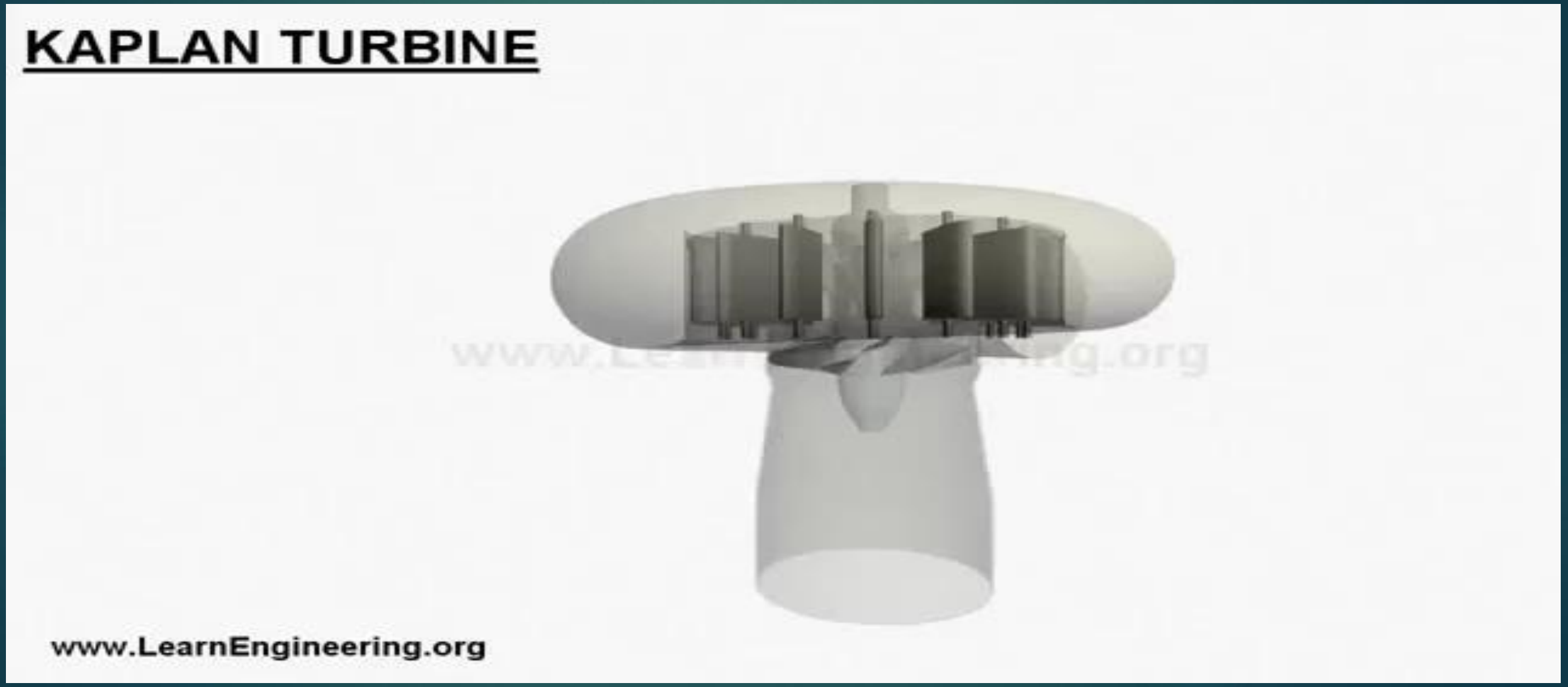
Use of Turbine

- Hydraulic turbines are used to convert the power of flowing water into usable electrical or mechanical power.
- The turbine design is dictated by the head on the turbine and the discharge through the turbine.
- In low head plants (6-100 ft) with moderate to high discharge, the propeller type of turbine is most often used.
- Some propeller type turbines have adjustable blades to effect *higher efficiencies* over a wide range of flow conditions. These are called Kaplan turbines.





Kaplan Turbine – Axial Flow



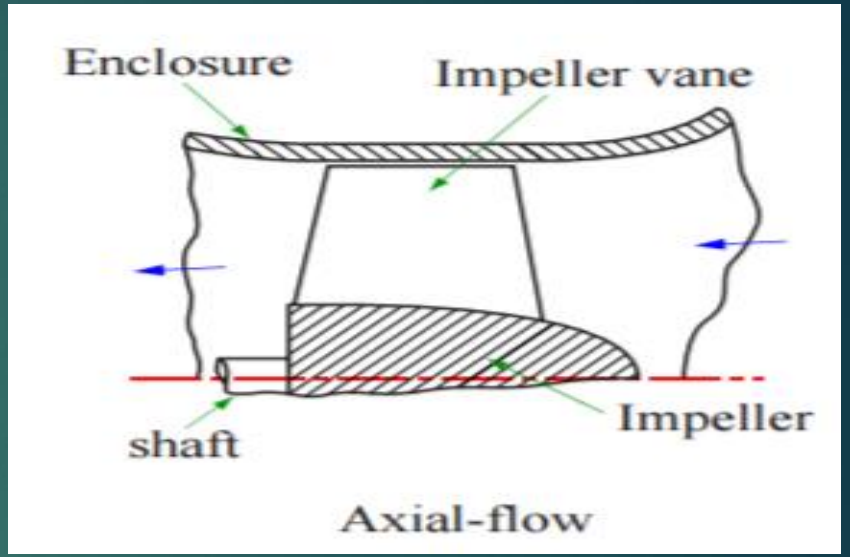
Cavitation, Pumps and Turbines

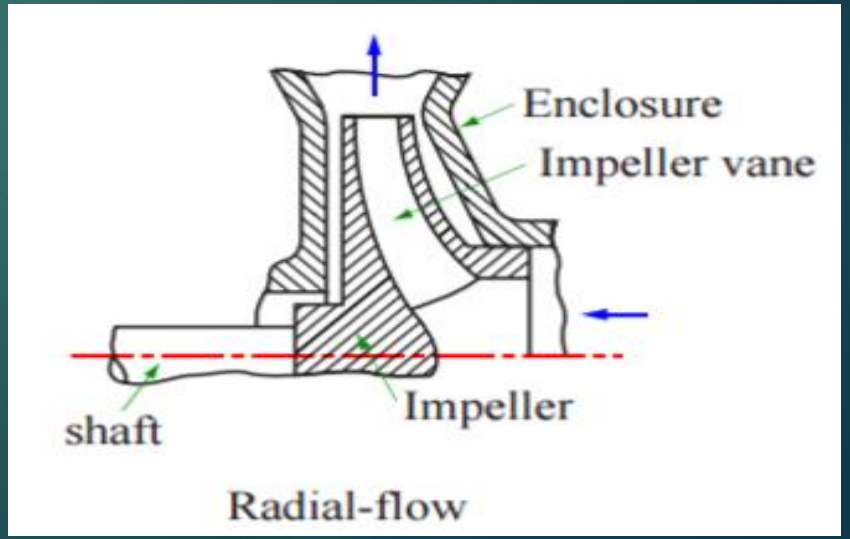
Use of Pumps

- In hydraulic engineering, we are primarily interested in pumps for irrigation, flood control, water supply, wastewater, and thermal power plant cooling system.
- The design of the pump is primarily dedicated by the discharge rate and head to be developed by the pump.
- Another design consideration is the clarity of the water to be pumped.
- Is it clear water from a lake or well, or is it wastewater that may contain sediment particles or debris?

Axial and Radial Flow Pumps

- An axial-flow pump, or AFP, is a common type of pump that the fluid enters and exits along the same direction *parallel* to the rotating shaft.
- A radial flow pump is a ***centrifugal*** pump where the fluid being pumped is discharged radially, i.e. at right angles to the pump shaft.
- Axial flow pumps operate at much lower pressures and higher flow rates than radial flow pumps.
- Centrifugal pumps are typically used for large discharge through smaller heads.





Axial Pump

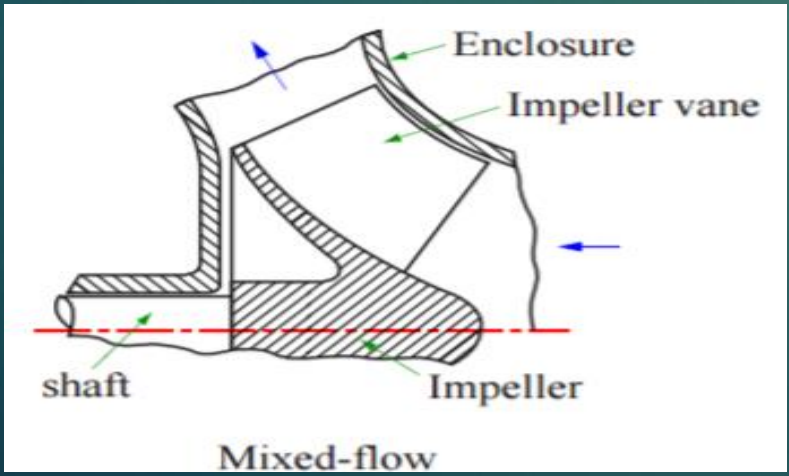
What is an **Axial Flow Pump**?

Centrifugal Pump

CENTRIFUGAL PUMPS

Mixed Flow Pumps

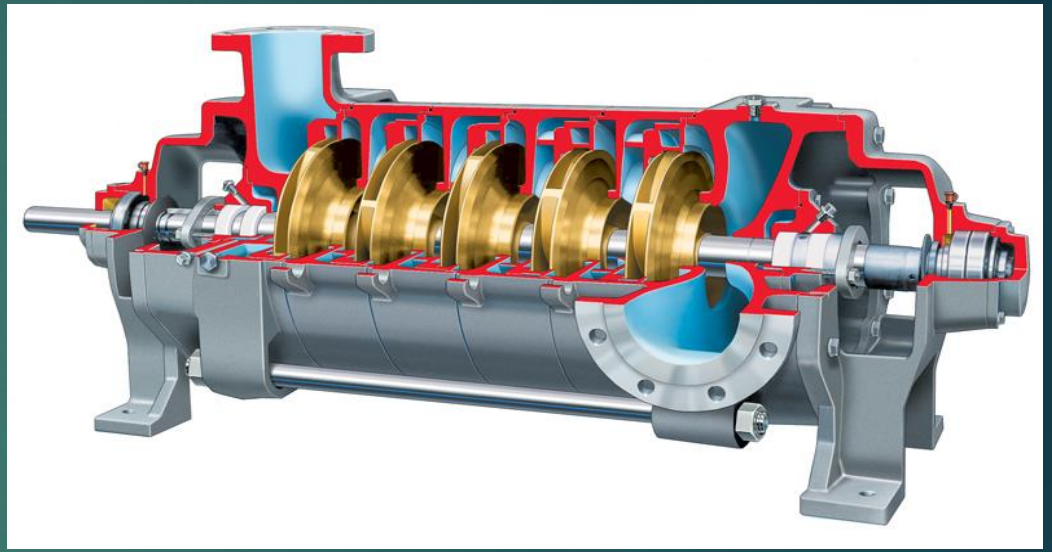
- Mixed-flow pumps function as a compromise between radial and axial-flow pumps.
- As a consequence mixed-flow pumps operate at higher pressures than *axial-flow* pumps while delivering higher discharges than *radial-flow* pumps.

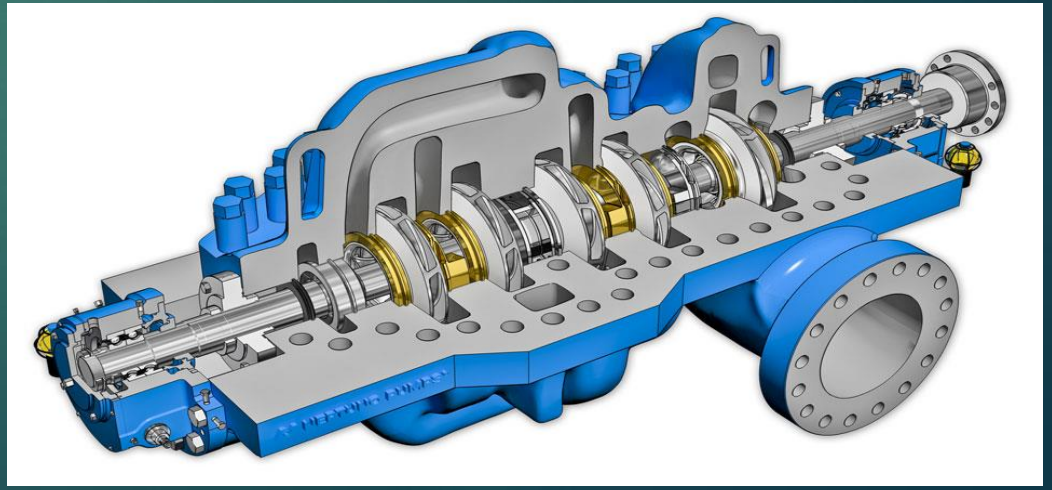


What is a **Mixed Flow Pump**?

Multi Stage Pumps

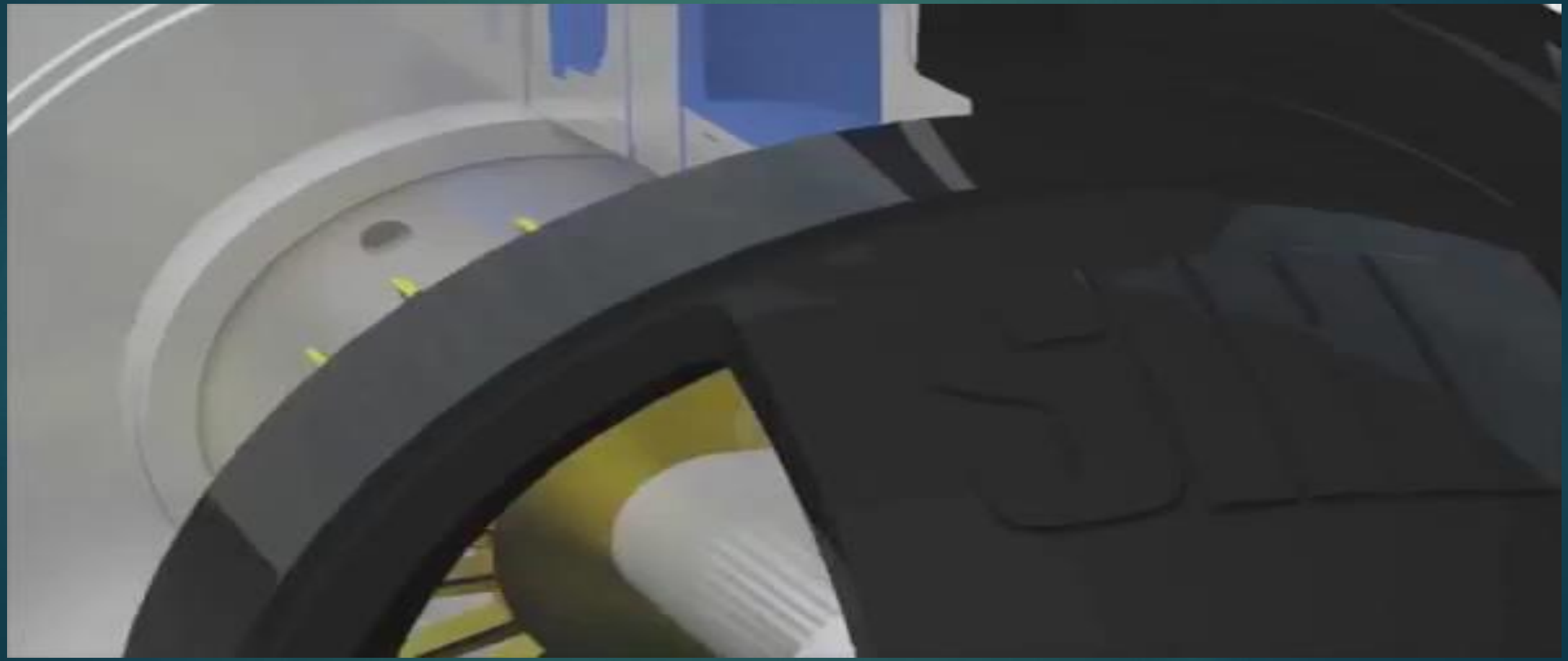
- A centrifugal pump containing two or more impellers is called a multistage centrifugal pump.
- The impellers may be mounted on the same shaft or on different shafts.
- For higher pressures at the outlet, impellers can be connected in series. For higher flow output, impellers can be connected parallel.





Cavitation, Pumps and Turbines

Multi Stage Pump



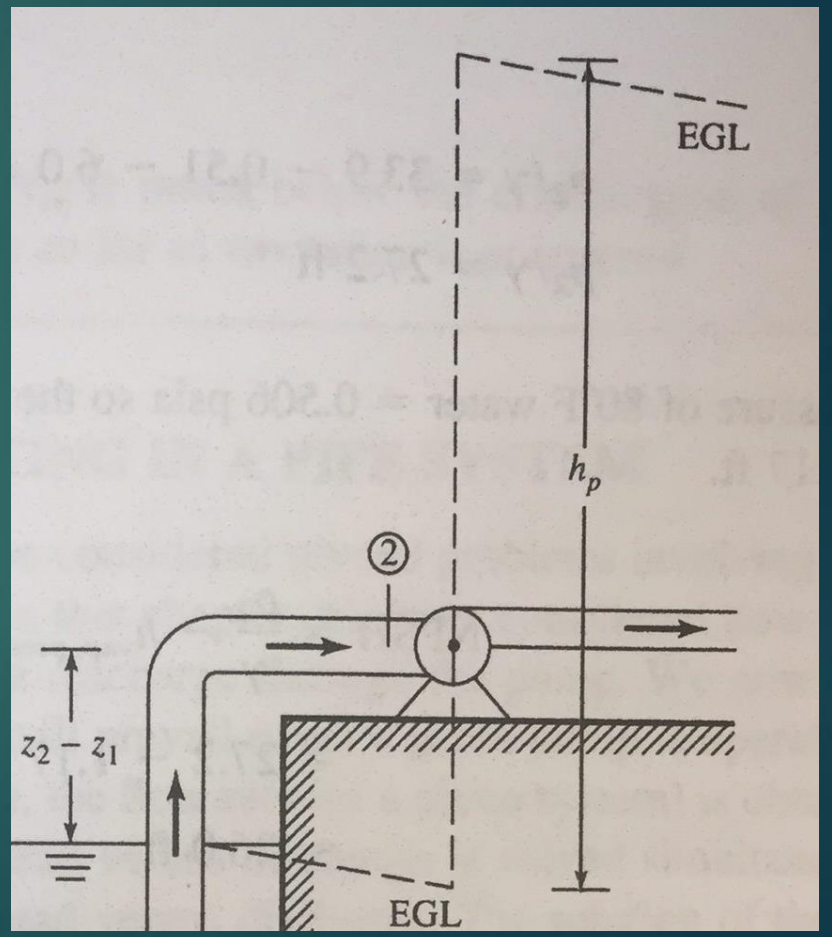
Cavitation, Pumps and Turbines

Cavitation in Pumps

- The pressure at the suction side of a pump is most significant as to weather or not a pump will cavitate.
- As water flows past the impeller blades of a pump, locally high velocity flow zones, produces low relative pressure (Bernoulli effect), and if the pressure reach the vapor pressure of the liquid the cavitation will occur.
- The significant pressure is the difference between the *absolute pressure* on the suction side of the pump and the *absolute vapor pressure* of the liquid being pumped.

Cavitation, Pumps and Turbines

- In practice this difference (*absolute pressure* and *absolute vapor pressure*) is called the Net Positive Suction Head (**NPSH**).
- To calculate NPSH for a pump that is delivering a discharge, first we need to apply energy equation from the reservoir which water is being pumped to the section of intake pipe at the suction side of the pump.
- Then, subtract the vapour pressure head of the water to obtain NPSH.
- $NPSH_R$: The minimum pressure required at the suction port of the pump to keep the pump from cavitating (determined by manufacturer).



Cavitation, Pumps and Turbines

Example 1

The pump delivers 2 cfs flow 80 F water and the intake pipe diameter is 8 in. The pump intake is located at the water surface level in the reservoir. What is the net positive suction head (NPSH) for these conditions.

Assume entrance loss coefficient is 0.1, head loss coefficient is 0.2, neglect pipe friction loss, and $NPSH_R$ is 10.