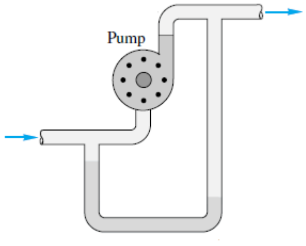
بسم الله الرحمن الرحيم

Mechanical Engineering (2)



Fayoum University

Faculty of Engineering
Mechanical Engineering Dept.

Lecture (6)

on

Application of Fluid Mechanics

(Hydraulic Machines)

By

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Application of Fluid Mechanics

Applications to power generation:

1. Pumps,
2. Fans,
3. Turbines,
4. Compressors,
5. Hydraulic and pneumatic control systems.

Pumps

Introduction and Classification

Turbomachines divide naturally into those which add energy (pumps) and those which extract energy (turbines). The prefix *turbo-* is a Latin word meaning "spin" or "whirl," appropriate for rotating devices.

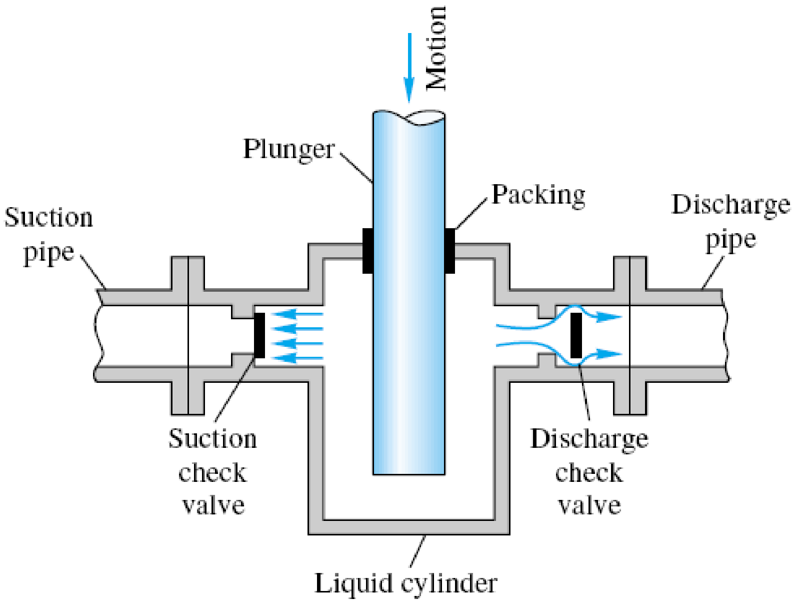
1. Positive-displacement pumps

A. Reciprocating
   1. Piston or plunger
   2. Diaphragm

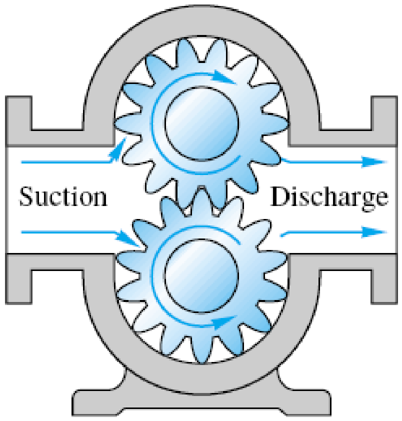
B. Rotary
   1. Single rotor
      a. Sliding vane
      b. Flexible tube or lining
      c. Screw
      d. Peristaltic (wave contraction)
   2. Multiple rotors
      a. Gear
      b. Lobe
      c. Screw
      d. Circumferential piston

Pumps

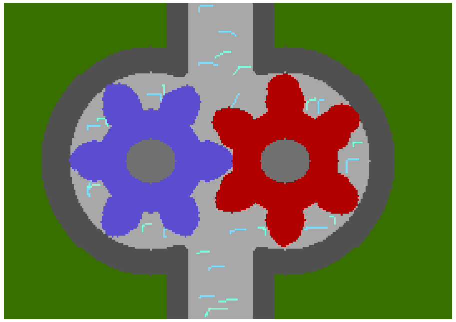
1. Positive-displacement pumps

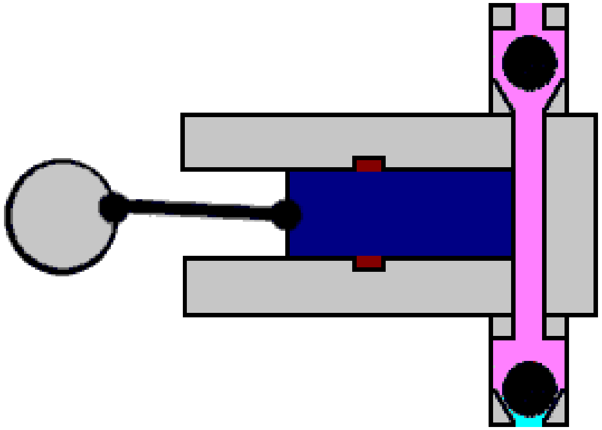


reciprocating piston or plunger.



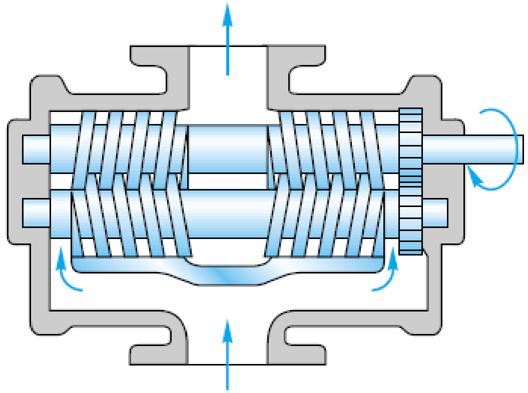
external gear pump.



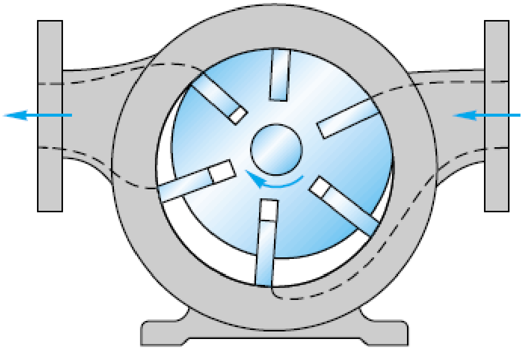


Pumps

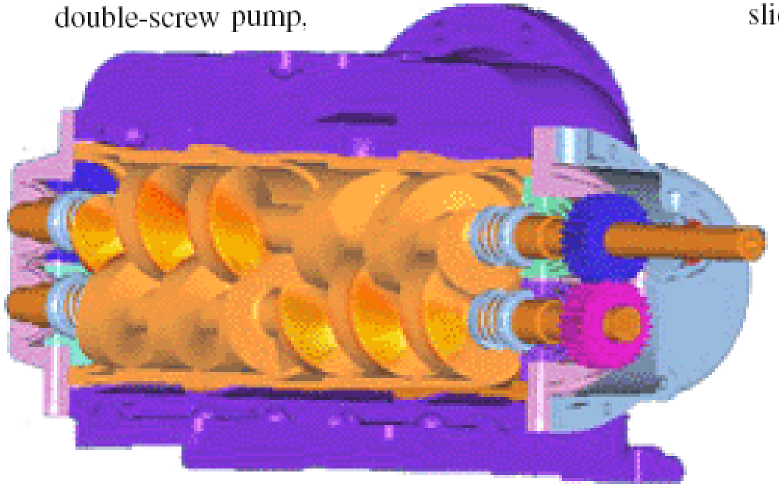
1. Positive-displacement pumps

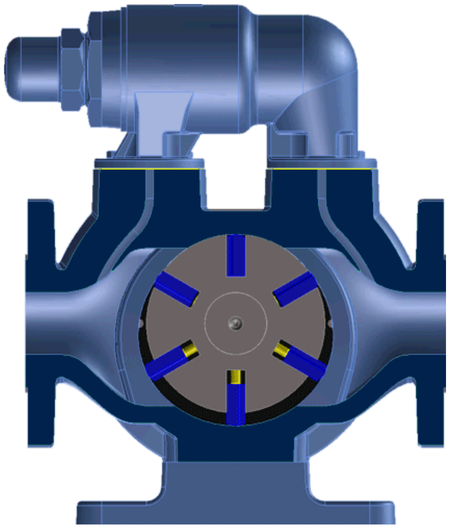


double-screw pump,



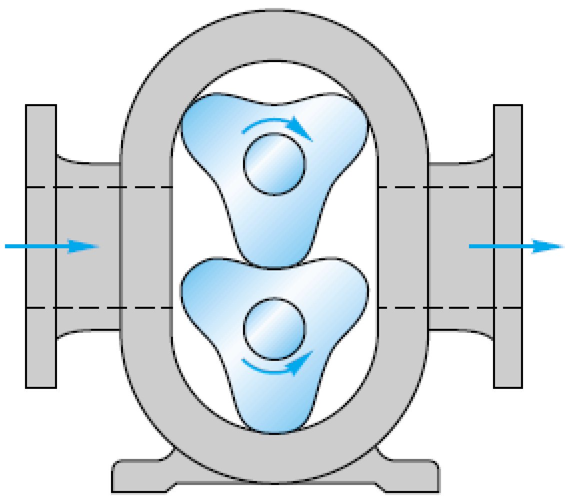
sliding vane,



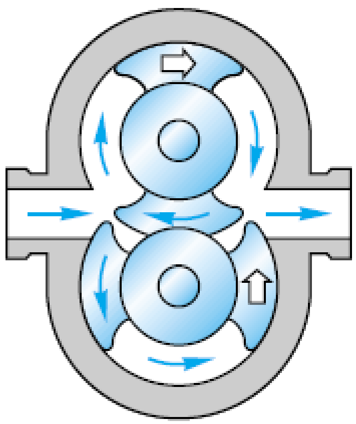


Pumps

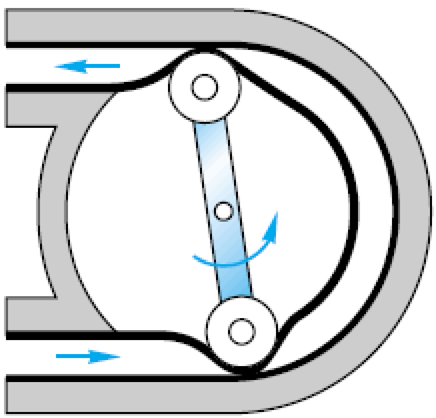
1. Positive-displacement pumps



three lobe pump,



double circumfer ential piston,



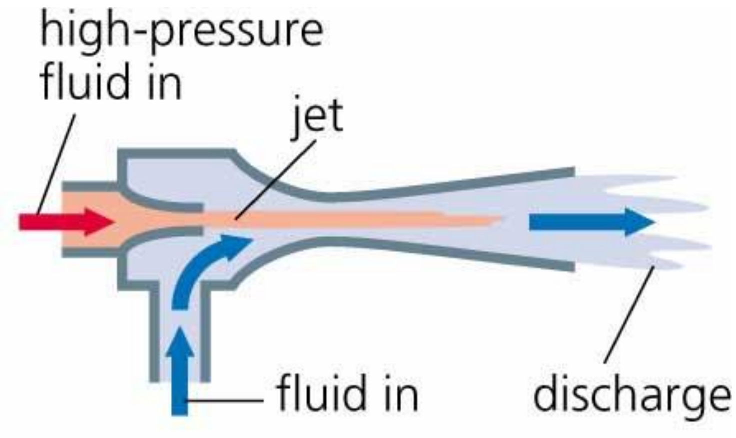
flexible-tube squeegee.

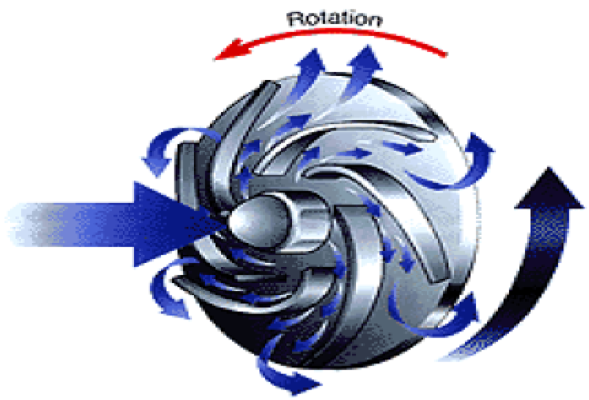
Pumps

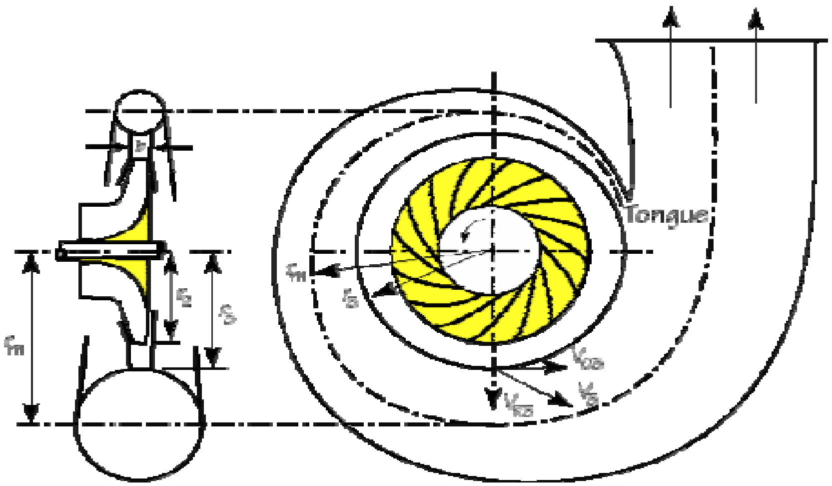
2. Dynamic pumps

A. Rotary
   1. Centrifugal or radial exit flow
   2. Axial flow
   3. Mixed flow (between radial and axial)

B. Special designs
   1. Jet pump or ejector
   2. Electromagnetic pumps for liquid metals
   3. Fluid-actuated: gas-lift or hydraulic-ram

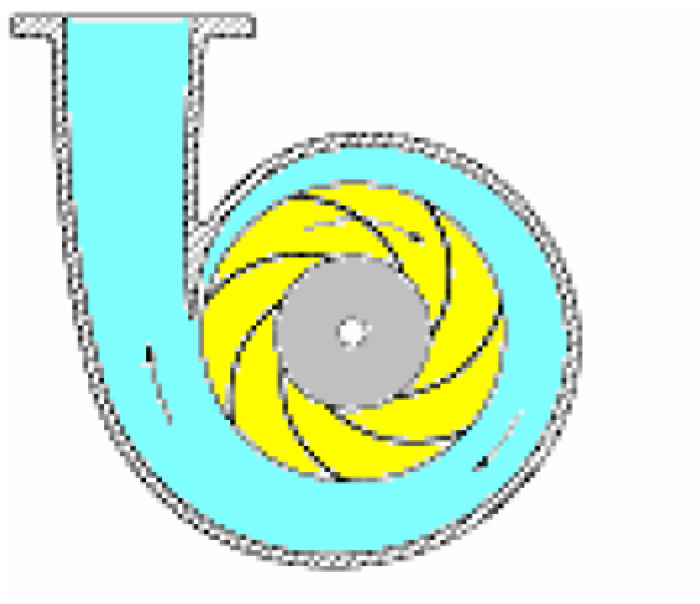




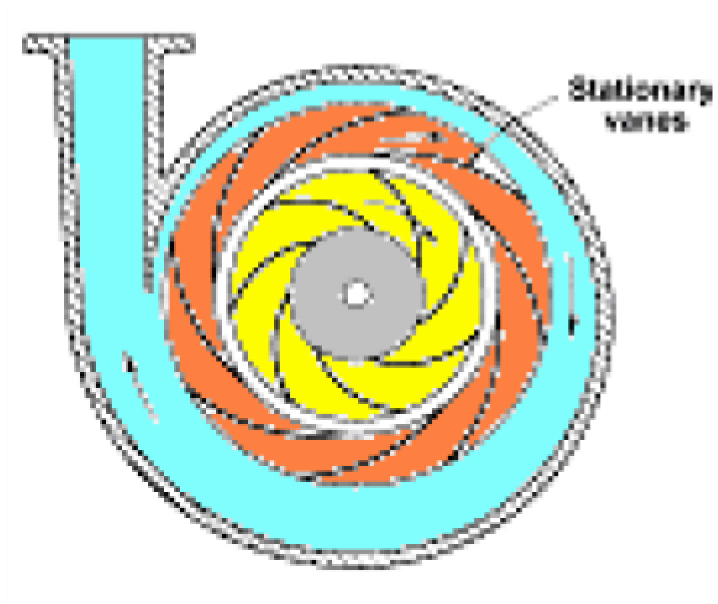


Pumps

The Centrifugal Pump Types



a. Volute Type



b. Diffuser Type

Impeller blades type

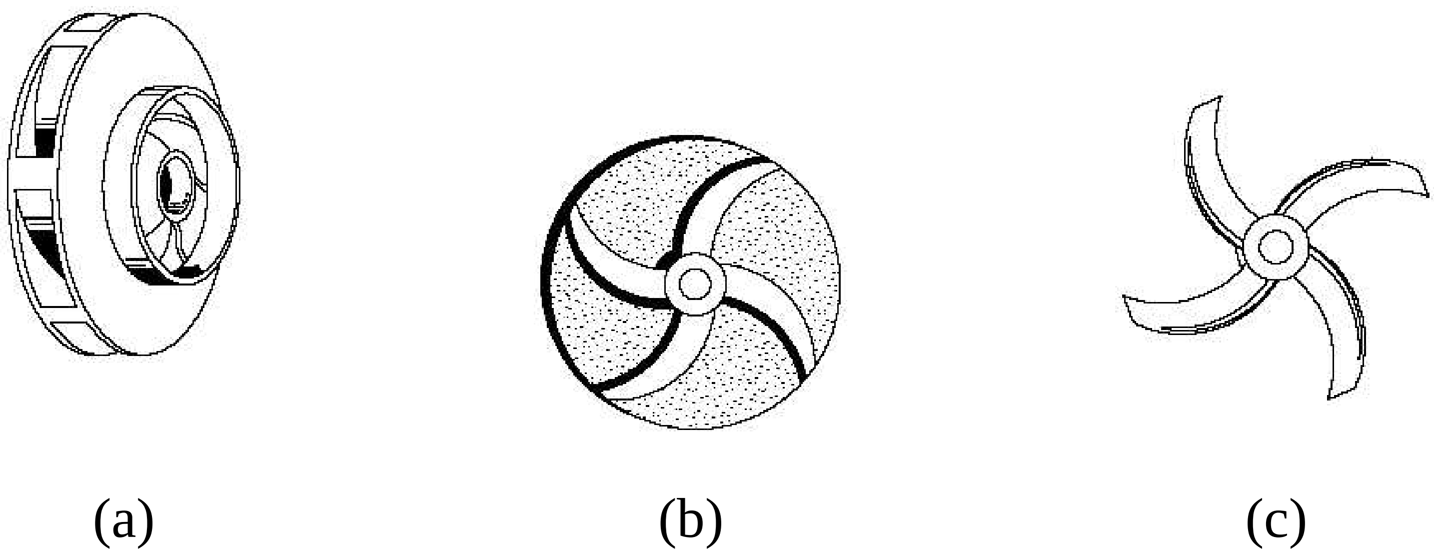


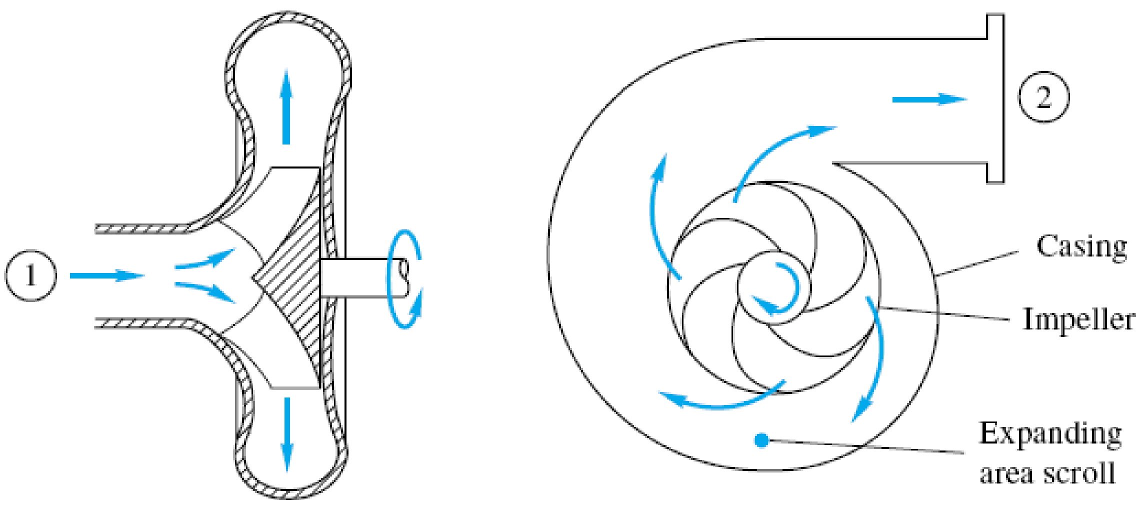
Fig. 4.4: Impeller blades type; Closes, (b) semi-closed, (c) open.

Pumps

The Centrifugal Pump

$$H = \left(\frac{p}{\rho g} + \frac{V^2}{2g} + z\right)_2 - \left(\frac{p}{\rho g} + \frac{V^2}{2g} + z\right)_1 = h_s - h_f$$

where h_s is the pump head supplied and h_f the losses.



The Centrifugal Pump

Usually V_2 and V_1 are about the same, $z_2 - z_1$ is no more than a meter or so, and the net pump head is essentially equal to the change in pressure head

$$H \approx \frac{p_2 - p_1}{\rho g} = \frac{\Delta p}{\rho g}$$ and *water horsepower.* $P_w = \rho g Q H$

brake horsepower $\text{bhp} = \omega T$ and $$\eta = \frac{P_w}{\text{bhp}} = \frac{\rho g Q H}{\omega T}$$

The *volumetric efficiency* $$\eta_v = \frac{Q}{Q + Q_L}$$ and The *hydraulic efficiency* $$\eta_h = 1 - \frac{h_f}{h_s}$$

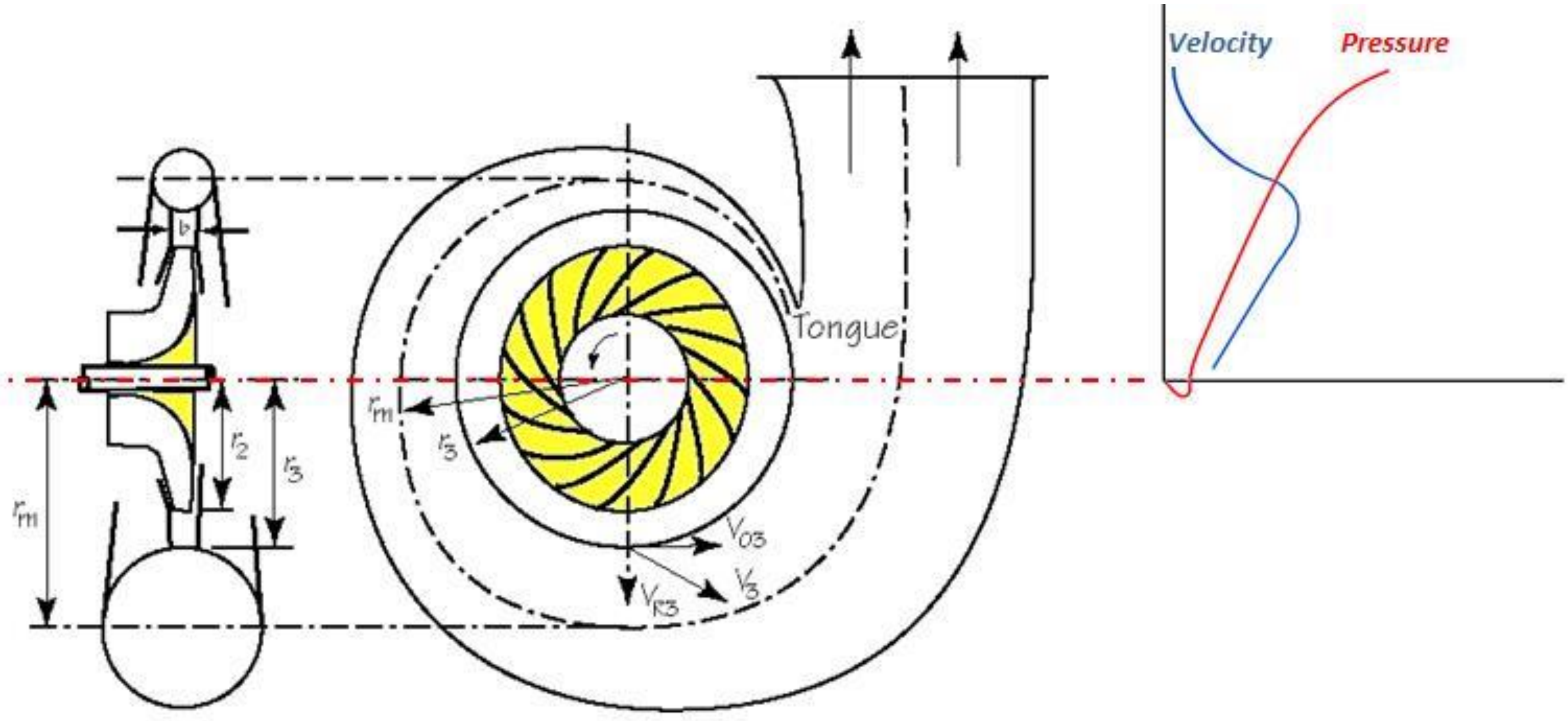
mechanical efficiency $$\eta_m = 1 - \frac{P_f}{\text{bhp}}$$

where P_f is the power loss due to mechanical friction in the bearings, packing glands, and other contact points in the machine.

the total efficiency $\eta \equiv \eta_v \eta_h \eta_m$

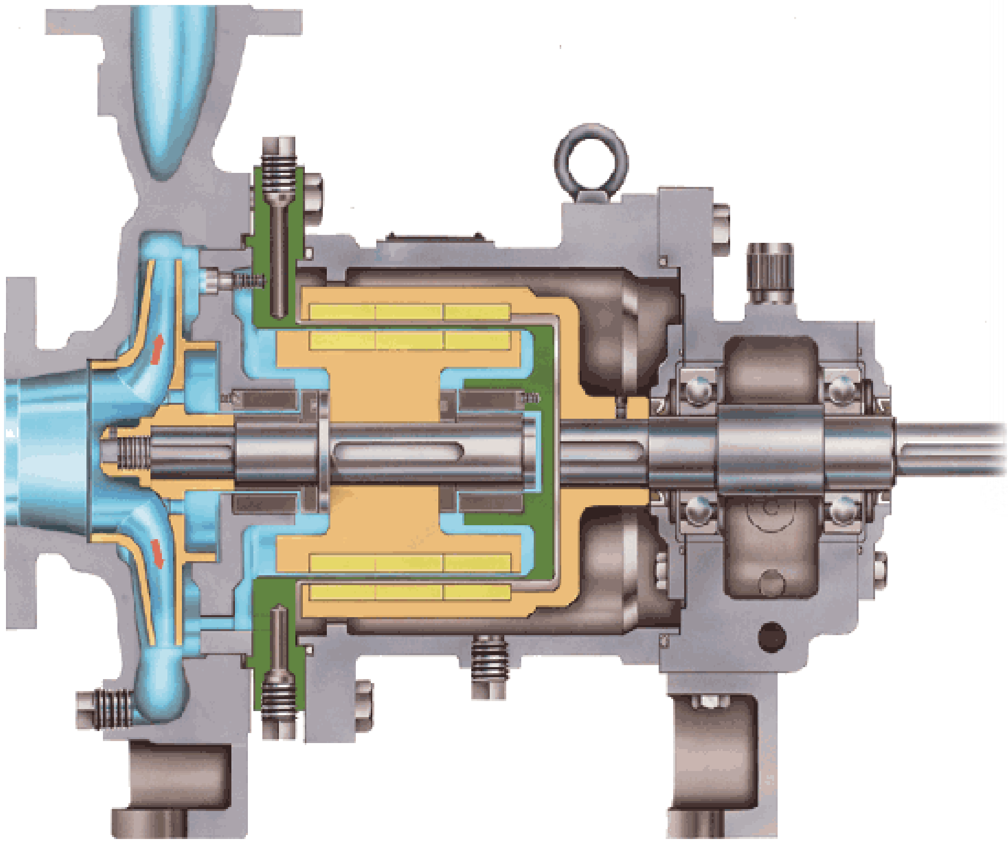
Pumps

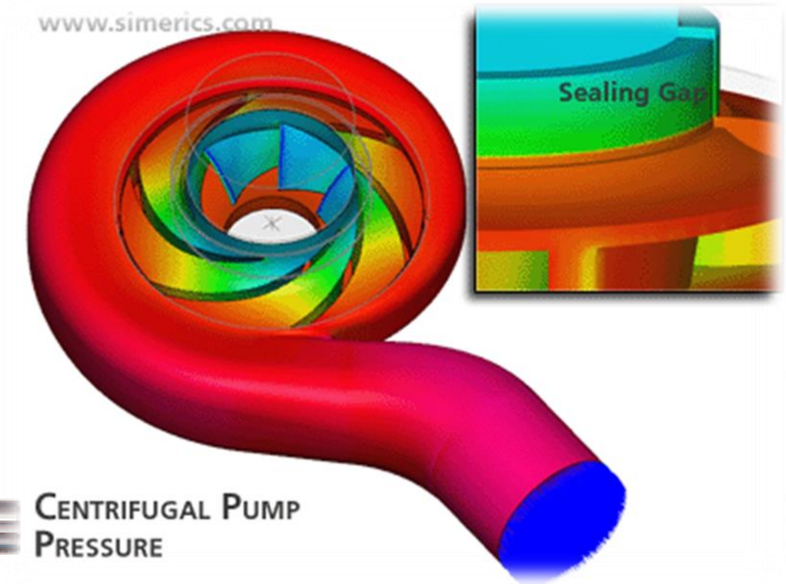
The Centrifugal Pump



Pumps

The Centrifugal Pump



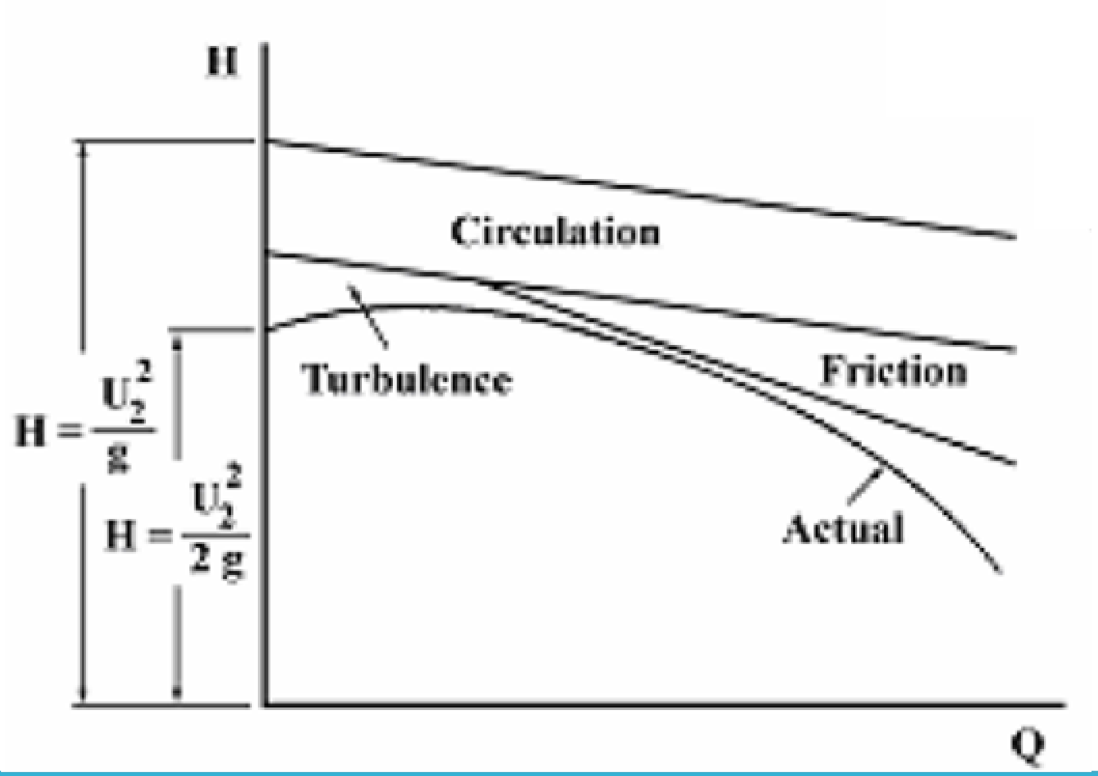


Centrifugal Pump Pressure

Pumps

Centrifugal Pump Actual Performance:

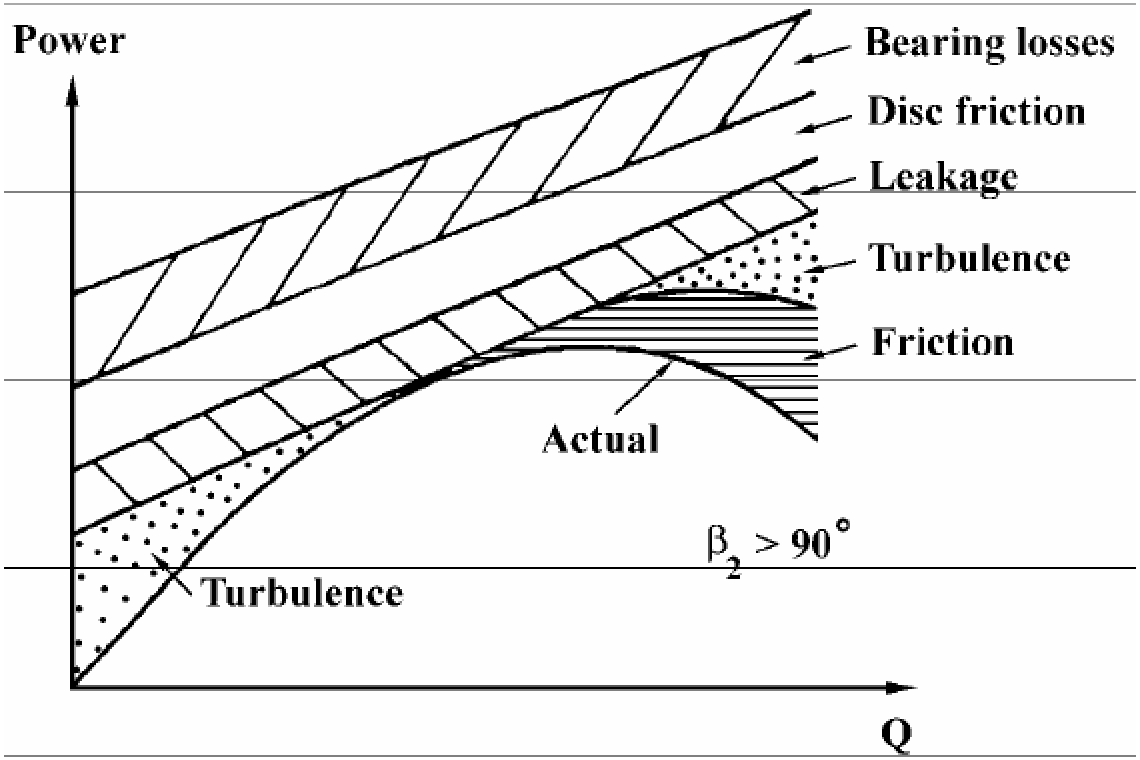
Actual Head Capacity Curve:



Pumps

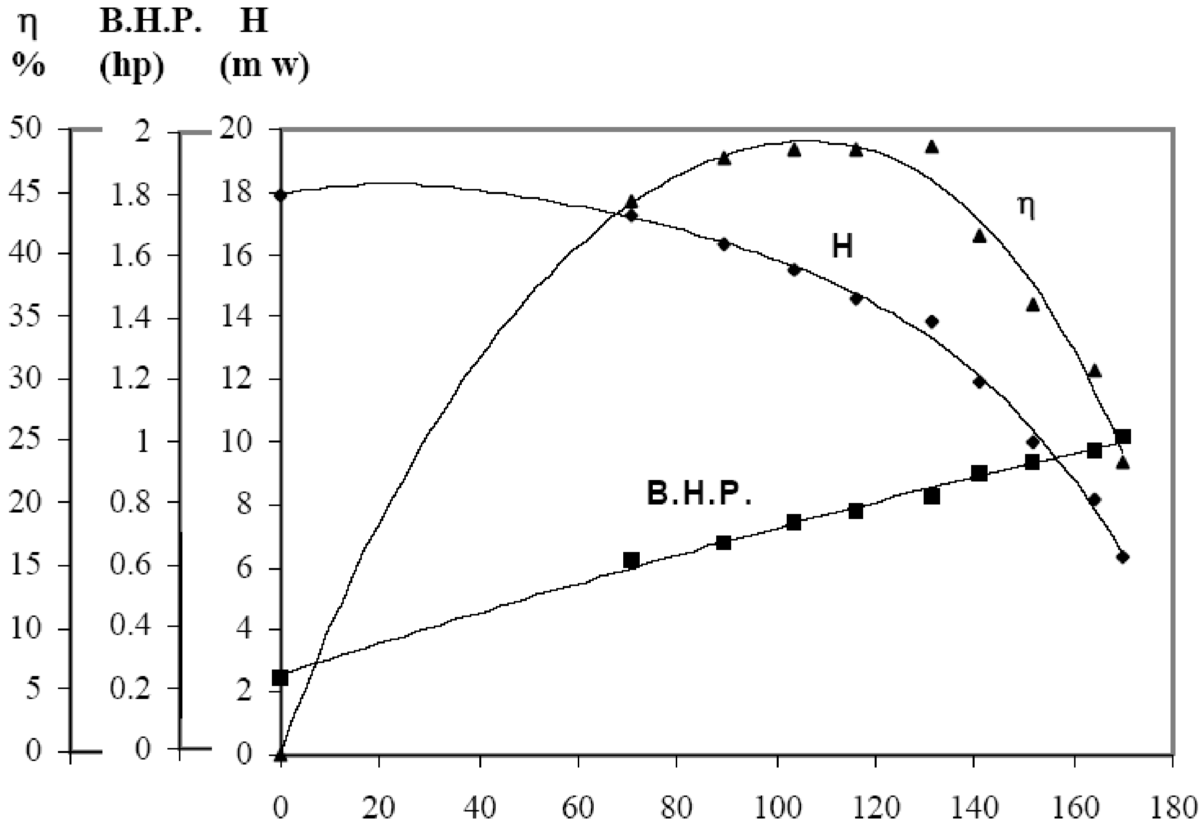
Centrifugal Pump Actual Performance:

Brake Horsepower and Efficiency Curves:



Pumps

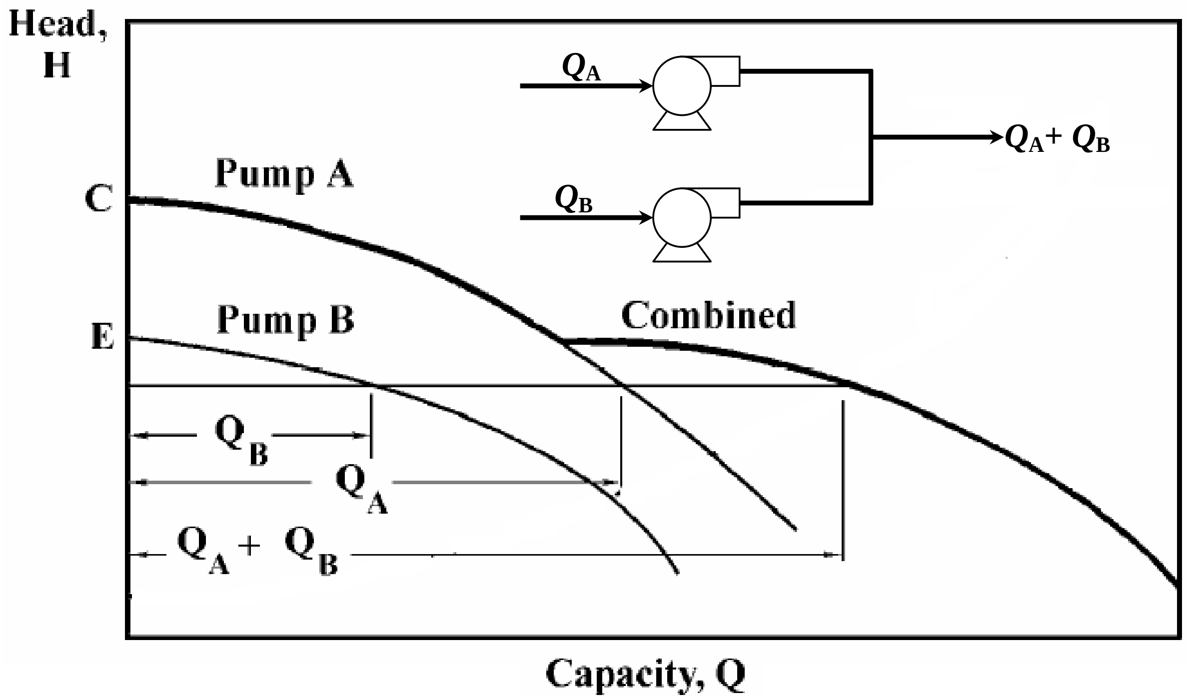
Centrifugal Pump Actual Performance:



Parallel and series operation

Pumps in Parallel: Usually used when large capacities are required

$$\eta = \rho g H \frac{\sum Q}{\sum BHP}$$

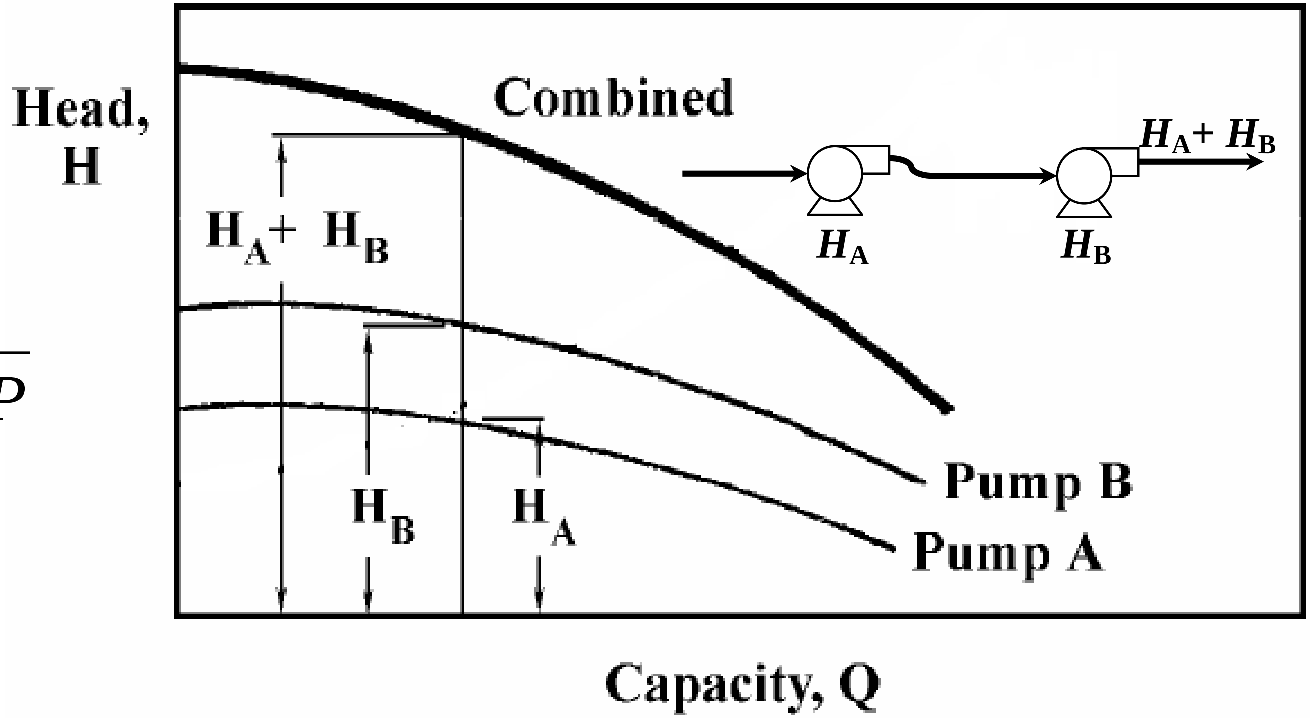


Pumps in parallel

Parallel and series operation

Pumps in Series: When a high head is required,

$$\eta = \rho g Q \frac{\sum H}{\sum BHP}$$



Pumps in series

Positive-displacement pumps

Reciprocating Pump

$$Q = \frac{\pi}{4} D^2 \frac{2\,r\,n}{60}$$

where: D = diameter of ram
r = crank radius
n = speed in r.p.m.

The swept volume $= \dfrac{\pi}{4} D^2 .2\,r$