University of Mosul

College of Petroleum & Mining Engineering

Fluid Flow II

Lecture (3)

Fluid Dynamic

Petroleum and Refining Engineering Department

Ass.P. Raqeeb Hummadi Rajab

Ass.L. Ghufran Faris Alrahhawi

Email: ghufranalrahhawi @uomosul.edu.iq

LECTURE CONTENTS

Application of Bernoulli's Equation

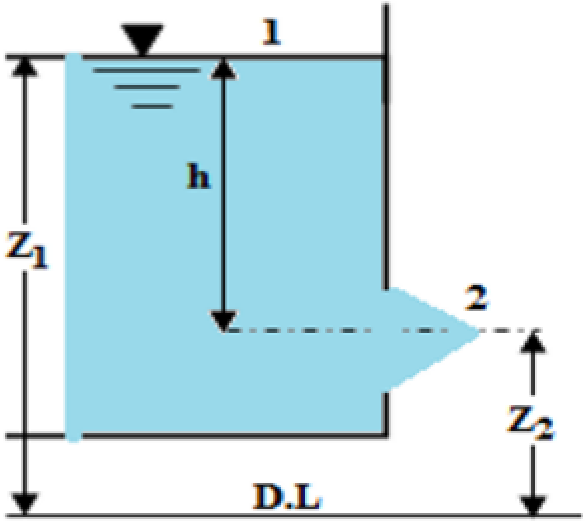
Application of Bernoulli's equation:

1. Torricelli's theorem

A1-surface area of liquid at '1' $A_1 >> A_2$

Points '1' and '2' are both exposed to atmospheric pressure i.e. $p_1 = p_2 = 0$

applying Bernoulli's equation between points 1 and 2



$$\frac{P_1}{\gamma} + \frac{{V_1}^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{{V_2}^2}{2g} + z_2$$

$V_1 = 0$ large tank P_1 and P_2 =0 atmospheric pressure

$$\frac{{V_2}^2}{2g} = z_1 - z_2 \qquad z_1 - z_2 = h$$

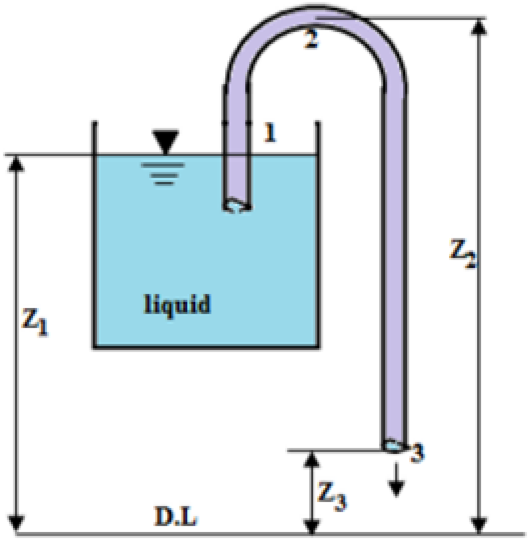
$$V_2 = \sqrt{2gh}$$ Torricellis equation

2.Siphon

Conditions for siphon performance:

- Z1 > Z3
- Initially the fluid must be forced to flow.

$$(z_2 - z_1) < P_{atm}$$



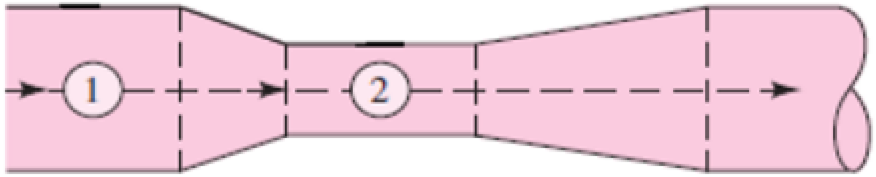
3. closed duct or pipe:

In this case p1 and p2 not equal zero; $Z_1 = Z_2$

$$\frac{P_1}{\gamma} + \frac{{V_1}^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{{V_2}^2}{2g} + z_2$$

Applying continuity equation

$$A_1 V_1 = A_2 V_2$$



WORK – ENERGY EQUATIONS

a) Energy: 1. Added mechanically →(pump)

2. Removed: a. mechanically →(turbine)

b) Frictional resistance (losses)

1) Valves 2) elbows 3) reducers

- Bernoulli's equation may be modified to account for energy added or energy removed between any two points in the flow.

Bernoulli's equation with pump:

$$\frac{P_1}{\gamma} + \frac{{V_1}^2}{2g} + z_1 + E_p = \frac{P_2}{\gamma} + \frac{{V_2}^2}{2g} + z_2$$

Bernoulli's equation with turbine:

$$\frac{P_1}{\gamma} + \frac{{V_1}^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{{V_2}^2}{2g} + z_2 + E_T$$

For real flow with losses:

$$\frac{P_1}{\gamma} + \frac{{V_1}^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{{V_2}^2}{2g} + z_2 + H_L$$

Where, E_p = pump head (m)

E_T = turbine head (m)

H_L =head loss (m)

Pump power

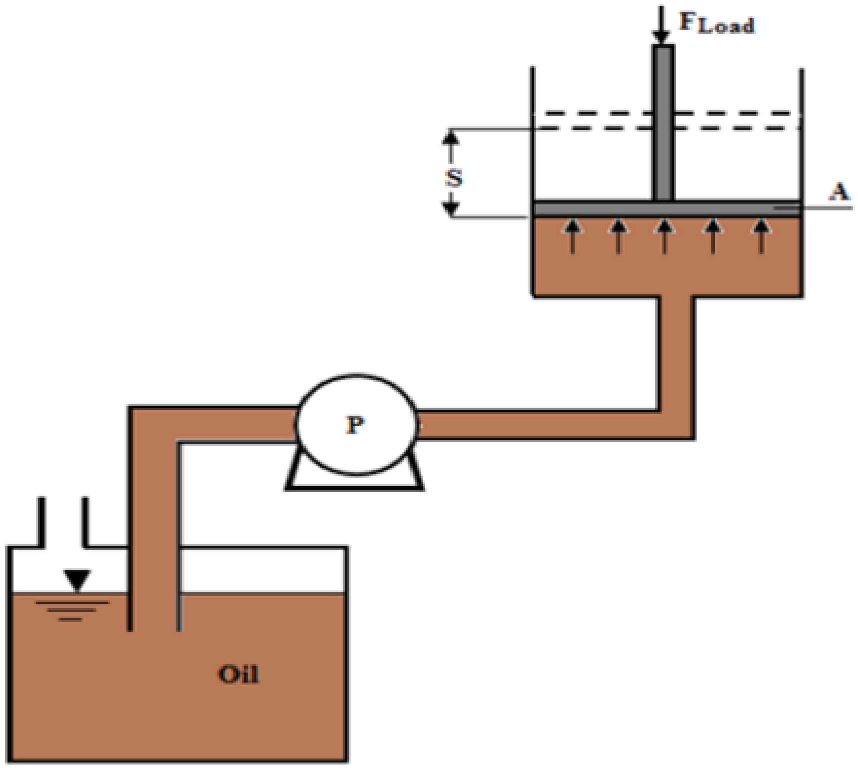
$$\boldsymbol{P_{pump} = \gamma Q E_p}$$

Turbine power

$$\boldsymbol{P_{Turbine} = \gamma Q E_T}$$

$F_{Load} \times S = work$ (J)

$Power = F \times \frac{s}{t} = (\frac{J}{s})$ or watt



$Power = PAV = PQ$ but $P = \gamma E_p$

Output power from the pump which is less than the electrical power input to the pump

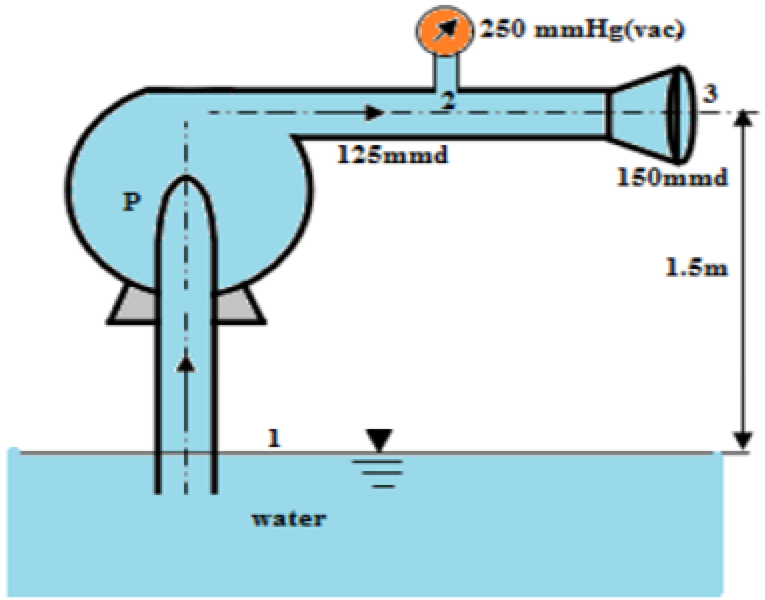
Example (1)

Calculate the pump power, assuming that the divergent tube flow full

Solution

$$P_2 = \gamma_{Hg} h_{Hg}$$

$$P_2 = -13570 \times 9.81 \times 0.25 = -33280 \text{ Pa}$$



Applying Bernoulli's equation

$$\frac{P_2}{\gamma} + \frac{{V_2}^2}{2g} + z_2 = \frac{P_3}{\gamma} + \frac{{V_3}^2}{2g} + z_3$$

$$z_2 = z_3 \quad P_3 = 0 \text{ atm}$$

$$\frac{-33280}{9810} = \frac{V_3^2 - V_2^2}{2g}$$

$$V_3^2 - V_2^2 = -66.56 \qquad \ldots\ldots\ldots (1)$$

$$A_2 V_2 = A_3 V_3$$

$$V_2 = \frac{A_3}{A_2} = \frac{150^2}{125^2} V_3 = 1.44 V_3 \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$