

# **CHME 302 CHEMICAL ENGINEERING LABOATORY-I EXPERIMENT 302-III**

## **CENTRIFUGAL PUMP PERFORMANCE TEST SETUP**

### **1. OBJECTIVE:**

The purpose of this experiment is to determine the characteristics of a centrifugal pump and use the concepts of similitude to generalize its performance. Similitude results will be compared with the real pump characteristics. Also, net positive suction head required for the pump is determined.

### **2. EXPERIMENTAL SETUP**

Pumps are turbo machines transferring mechanical energy into fluid energy. The energy of the fluid is increased through the pump. This energy is supplied by the impeller, which in turn is driven by an electric motor or some other drive. In this experiment centrifugal pump is used (Domak SLG1” 1 HP).

In this experiment, pump system performance will be determined. The pump system is schematically described in Figure-1 the flow rate is adjusted from the discharge valve, located after the pump. Bourdon gages are mounted at the suction and discharge sides of the pump. The flow rate is measured using rotameter (variable area flow meter). A rotameter is a vertically installed device, which operates when the upward fluid drag on the float is balanced by the weight of the float. The float operates in a diverging tube. Float and the tube geometry and material depend on the range of operation of the rotameter. Power analyzer is used for measuring, volt, amper and power factor which are used for obtaining the power input to the motor of the centrifugal pump.

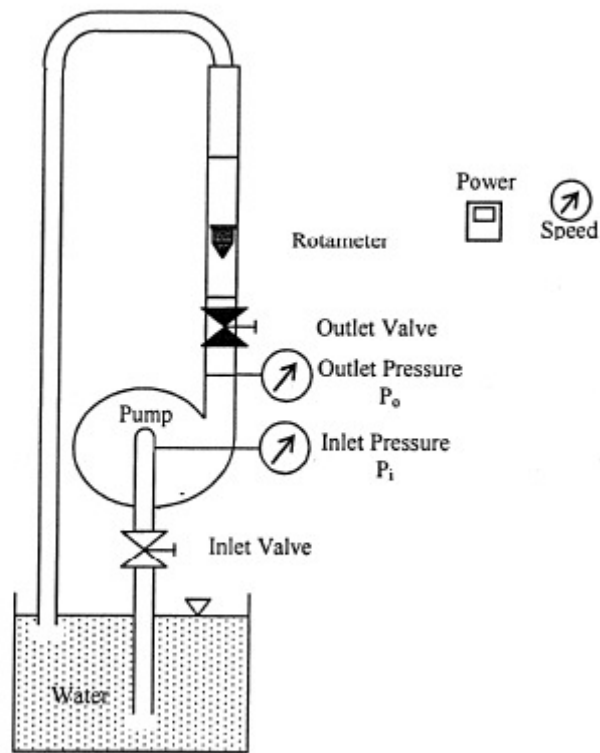


Figure 1. Experimental Setup

### **3. PUMP CHARACTERISTICS**

#### **3.1 Experimental Procedure:**

In the first part of the experiments, the pump characteristics are determined.

1. Record the atmospheric pressure and the water temperature.
2. Make sure that water tank contains sufficient amount of water.
3. Open the inlet and outlet valves fully.
4. Start the pump by starting the electric motor.
5. Select a speed at which to run the pump. Adjust pump speed  $N_{\text{pump}}$  to this selected value.
6. Record data for 8 different flow rates ranging between  $Q=0$  and  $Q=Q_{\text{max}}$ . Flow rate will be varied by adjusting the outlet valve. At each flow rate data below will be recorded:

- i) Pump speed (set to chosen value)  $N_{\text{pump}}$  (rpm).
- ii) Motor Power (Input)  $P_{\text{motor}}$  (kwatt)
- iii) Pump inlet Pressure  $P_i$  (mmHg)
- iv) Pump Outlet Pressure  $P_o$  (bar)
- v) Flow Meter Reading  $Q$  (m<sup>3</sup>/h)

7. You will now obtain pump characteristics at a different speed. Open the inlet valve fully. Select a new rotational speed and adjust the pump to this speed.
8. Repeat step 6 at the new flow rate.

**Important:** Always record your data after the system reaches steady operating conditions. During data recording, do not forget to readjust the pump speed, which may change a little due to flow rate change, in order to obtain a constant  $N_{\text{pump}}$ .

### **3.2 Calculations**

1. using the extended Bernoulli equation between the suction and discharge sides of the pump, determine the pump head  $H_{\text{pump}}$  (m), assuming no loss.

$$H_{\text{pump}} = \frac{P_o - P_i}{\rho \cdot g} + \frac{V_o^2 - V_i^2}{2 \cdot g}$$

Inlet and outlet velocities are to be determined from measured flow rates.  $\rho$  and  $g$  are respectively density of the fluid and gravitational acceleration.

2. Calculate the fluid power. ( $P_{\text{fluid}}$ )

$$P_{\text{fluid}} = \rho \cdot g \cdot Q \cdot H_{\text{pump}}$$

3. Calculate the power input to the motor.

$$P_{\text{motor}} = P_{\text{display}}/100$$

4. Calculate the overall efficiency.

$$\eta = \frac{P_{fluid}}{P_{motor}}$$

5. Tabulate H and  $\eta$  with respect to flow rate (Q)

6. Plot H vs. Q and  $\eta$  vs Q on the same graph as series for each pump speed worked with.

In constructing the characteristic curves, mark the points combine them.

#### **4. CAVITATION**

Cavitation can be defined as the operating condition where working liquid evaporates due to low pressure, i.e. vapor bubbles are about to be formed at the point of lowest, suction side pressure on the rotor or stator vane in a pump. The frequently experienced cavitation damage is caused by the collapse of these bubbles further downstream after they have moved into the higher pressure regime. Cavitation can be avoided when the minimum suction surface pressure is higher than the vapor pressure of the fluid. Cavitation is most likely to occur on the suction side of the pump, between the spwer reservoir surface and the pump inlet where the lowest pressure will occur. Every pump has a critical Net Positive Suction Head (NPSH). It is a measure of the energy available on the suction side of the pump. Minimum value of NPSH is determined by testing. Gate valve assembly used for cavitation is shown in Figure-1. Using the recorded data, calculate net positive suction head of the pump:

$$NPSH = \frac{P_{s_{abs}} - P_v}{\rho g} + \frac{V_s^2}{2g}$$

Where:

$P_{sabs}$  : absolute pressure at the pump suction side ( $P_i$ )

$P_v$ : absolute vapor pressure at working fluid temperature

$V_s$ : Pump suction side flow velocity

#### **4.1 Experimental Procedure**

- a) Record the ambient pressure and the temperature
- b) Start the pump by starting the electric motor. Adjust the pump speed  $N_{\text{pump}}$
- c) Close the gate valve at the suction side in order to throttle the flow.

#### **5. REFERENCES**

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