THE UNIVERSITY OF WESTERN ONTARIO DEPARTMENT OF MECHANICAL AND MATERIALS ENGINEERING

ES385Y "Selected Experiments in Mechanical Engineering" Experiment #15

The Performance of Centrifugal Pump

1. Introduction

The centrifugal pump is defined as a machine whose prime function is to pump or circulate liquid from one place to another place. Centrifugal pumps consist of a set of rotating vanes (see Figure 1), enclosed within a housing or casing, used to impart energy to a fluid through centrifugal force. The pump has two main parts: a rotating element which includes an impeller and a shaft, and a stationary element made up of a casing (volute of solid), stuffing box, and bearings. Centrifugal pumps operate using kinetic energy to move fluid utilizing an impeller and a circular pump casing. The impeller produces liquid velocity and the casing forces the liquid to discharge from the pump converting velocity to pressure. This is accomplished by offsetting the impeller in the casing, and by maintaining a close clearance between the impeller and the casing at the cutwater. The fluid enters the pump near the center of the impeller and is moved to its outside diameter by the rotating motion of the impeller. The vanes on the impeller progressively widen from the center of the impeller that reduces speed and increases pressure. This allows centrifugal pumps to produce continuous flows at high pressure. By forcing the fluid through without cupping it, centrifugal pumps can achieve a very high flow rate.

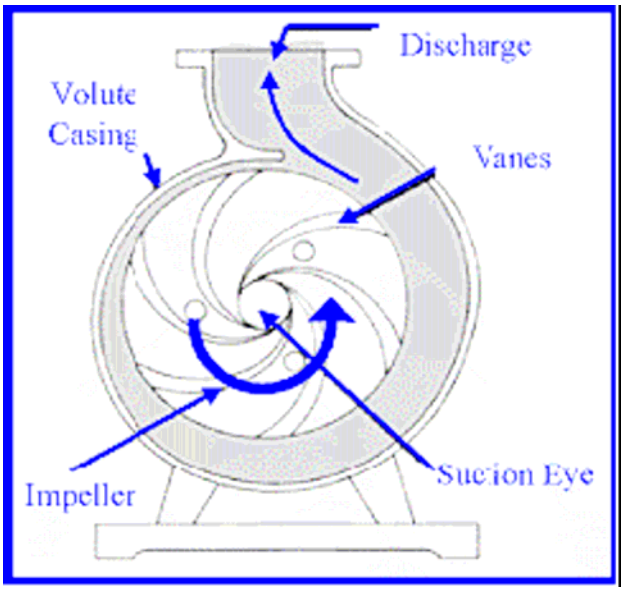

Figure 1 Centrifugal pump

2. Objectives

To investigate and establish the performance curves:

i) Head vs. Flow of the pump at constant rotating speed.

ii) Efficiency vs. Flow at constant rotating speed.

3. Principles and Background

Figure 2 shows the basic circuit of the Centrifugal pump.

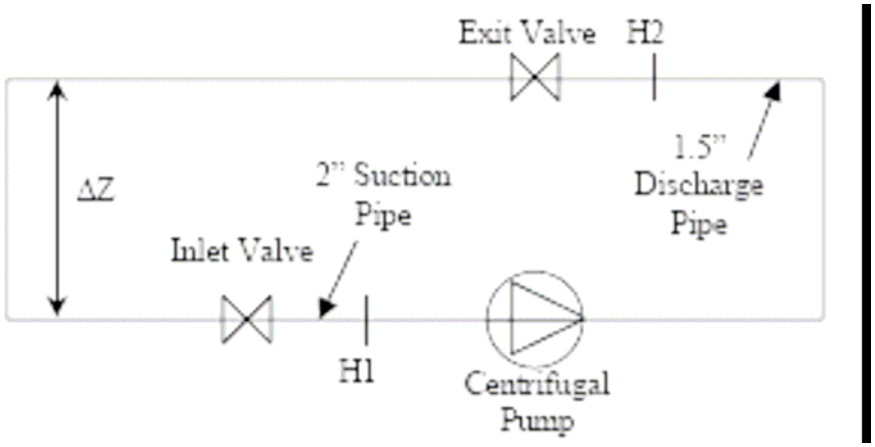

Figure 2 The centrifugal pump circuit

The basic concept of Steady one-dimensional fluid flow is given by the following equations:

i) Modified Bernoulli's (Energy) equation:

$$Z_1 + P_1/\gamma + \alpha_1 V_1^2/2g + H_{pump} = Z_2 + P_2/\gamma + \alpha_2 V_2^2/2g + \text{losses} \qquad (1)$$

Where H_{pump} is the head supplied by the pump [m].

ii) Power of pump:

$$N_{pump} = T * \omega \qquad (2)$$

Where:

T is the torque [N·m]

ω is rotating speed [rad/Sec]

iii) Hydraulic Efficiency:

$\eta = \gamma * H_{pump} * Q / N_{pump}$

Where :

Q is flow rate [m^3/Sec]
H is pressure head [m]

4. Apparatus

This experiment employs a PumpLab™ unit including Series 15H Inverter Control. Figure 3 shows picture of the unit.

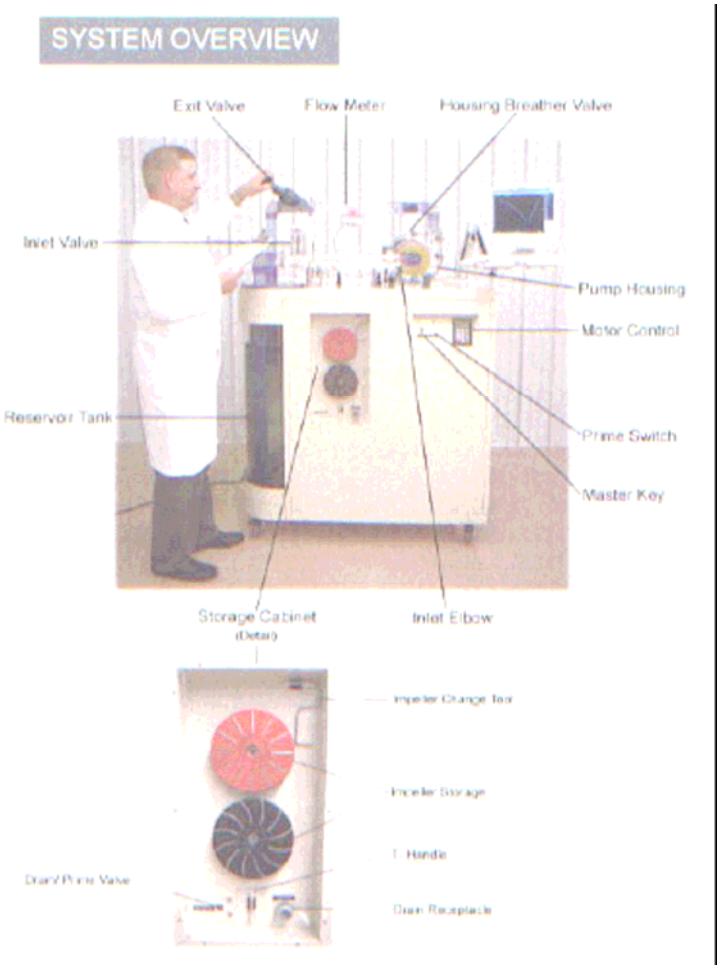

Figure 3 Picture of the PumpLab™

5. Procedure

1) Fill the reservoir tank.

2) Prime the flow circuit:
   a) Remove T-handle from holder (located directly below the stored impellers)
   b) Insert T-handle and turn valve to clockwise stop
   c) Open pump housing breather valve (located on top of the clear pump housing)
   d) Turn on prime toggle switch (assure that pump inlet and outlet valves are open)
   e) Close breather valve as water level reaches the top of the clear view impeller housing. If this is not done, water will spill out through the breather valve
   f) Turn master power key switch to on position
   g) Press forward button and increase on the specified motor rpm with up and down keys

3) Obtain and save the data:
   a) Run the pump with one speed which is given by the instructor
   b) Use computer to make record the data
   c) Select 10 points from fully open to fully close position of the exit valve, run for a period time for each points and make the record of data
   d) Use disc to save all the data and use the name showing the group name

6. Data Analysis and Discussion

1) Calculate the average of flow rate, inlet suction pressure and exit pressure at the specified rotating speed
2) Plot the value of head vs. flow rate.
3) Calculate H_{pump}, N_{pump} and hydraulic efficiency. **(Note that all the units to be used in the equations are SI units)**
4) Plot the hydraulic efficiency curve vs. flow rate.
5) Discuss the results and the curves.

7. Safety Consideration

The PumpLab™ unit should only be operated under the supervision of the laboratory demonstrator. No attempts should be made to start or stop the process except under the supervision of the laboratory demonstrator.

8. Prelab

1) The output data unit results will be saved as IP units: flow rate [gal/min], Head [ft] and rotating speed [RPM]. When you calculate the values you need to use SI unit: flow rate [m^3 / Sec], Head [m] and rotating speed [rad/Sec].
2) Describe the significance of each terms in the Energy **(Modified Bernoulli's)** equation.
3) Describe the curves of Head vs. Flow rate and Hydraulic Efficiency curve vs. Flow Rate using what you learned in fluid mechanics.
4) Which factors contribute to the uncertainty (error) in the results obtained from the data. How can you eliminate or reduce the effect of these factors?