

ME 4001
MECHANICAL ENGINEERING LABORATORY
Experiment 6: Pump Performance

Background:

A turbomachine is a device in which energy transfer occurs between a flowing fluid and a rotating element due to dynamic action, and results in a change in pressure and momentum of the fluid. Pumps are turbomachines that increase the pressure or head of flowing fluid [1]. Pumps are widely used in industry whenever a fluid is needed to be transported therefore, they constitute an unwavering component in pipeline systems.

The performance of a pump is measured in terms of its **head, H**, which is defined as the pressure rise across the pump divided the specific gravity of the fluid.

$$H = \frac{\Delta p}{\rho g} \quad (1)$$

Head of a pump typically depends on the rotation rate of the impeller and the volume flow rate of the fluid through the pump. An example performance curve for a pump is given in Figure 1.

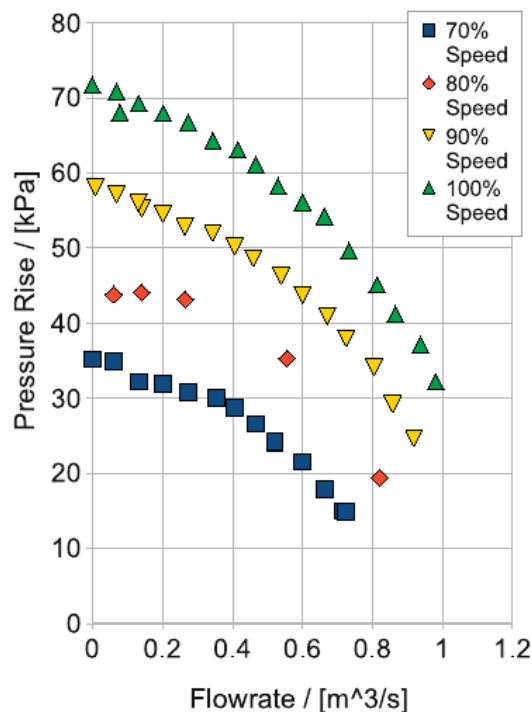


Figure 1. An example pump performance curve set [2]

Pump performance curves are very important for pump selection. Depending on the head requirements of the piping system the operating point of the pump will be specified by the intersection of the pump performance curve and the system curve. An example is shown In Figure 2. Another quantity that is included to Figure 2 is the pump efficiency. It is desired to have the operation point at the highest possible efficiency, which may not always take place. The efficiency of the pump motor system is defined as:

$$\eta_{pm} = \frac{\dot{m} g H}{\dot{W}_{elect}} \quad (2)$$

Where \dot{W}_{elect} is the electrical power supplied to the pump. For a motor running on DC current electrical power is calculated using:

$$\dot{W}_{elect} = V I \quad (3)$$

where V is the voltage difference and I is the electrical current.

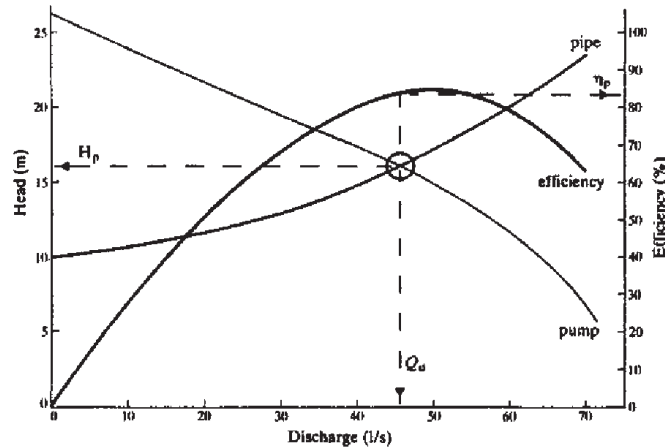


Figure 2. Pump– system interaction point and pump efficiency [1]

Equipment:

In this experiment the same experimental set up used during the Experiment 4 is going to be used. Therefore, the details of the equipment can be found in the instructions sheet of that experiment, hence will not be repeated here.

Experimental Procedure:

Filling the reservoir and Temperature measurement:

- *Pour 5 L of water into the reservoir*
- *Place the thermocouple wire tip inside the water in the reservoir*

Powering the Pressure Transducers:

- *Turn on the Power Supply connected to the Pressure Sensors*
- *Adjust the voltages to 20 V*

Controlling the flow rate through the voltage supply to Centrifugal Pump Motor:

- *Turn on the Power Supply connected to the Pump Motor*
- *Set the voltage to 20 V.*
- *Make sure that all the valve at the system is fully open.*

At the selected voltage read the pressure rise across the pump and the current when the valve is fully open.

Keeping the voltage constant decrease the flow rate three times by gradually closing the valve. At each reduced flow rate read the pressure rise across the pump and the current.

During the above steps, readings should be repeated three times for each condition in order to perform an uncertainty analysis.

Repeat the experiment for two other voltages selected by the group. These voltages should be less than 20 V.

For each voltage setting plot pump head and pump-motor efficiency vs. the volume flow rate on the same graph. You would produce figures similar to Figure 2 without the system curve.

Perform an uncertainty analysis by computing the mean, standard deviation and standard error of the mean for pump head and efficiency, and include the corresponding error bars on your figures.

References:

- [1] Gorla, R. S., & Khan, A. A. (2003). *Turbomachinery: design and theory*. CRC Press.
- [2] Ingram, G. (2009). *Basic concepts in turbomachinery*. Bookboon.