Characterization of a Centrifugal Pump

Alex Coker, Chemical Engineering

Mentor: Dr. Mingheng Li

Kellogg Honors College Capstone Project

Objective

To obtain a complete characterization of a selected high flow, low pressure centrifugal pump

Background

Centrifugal pumps work by increasing fluid velocity head using a spinning impeller. As shown in Figure 1, fluid enters the center of the impeller due to suction caused by the rotation of the impeller. As the fluid moves outwards along the vanes, its tangential velocity increases until it reaches the volute chamber, the open area on the right of the figure. The increasing area in the chamber causes the velocity head to be converted to pressure head. The fluid then exits the pump.

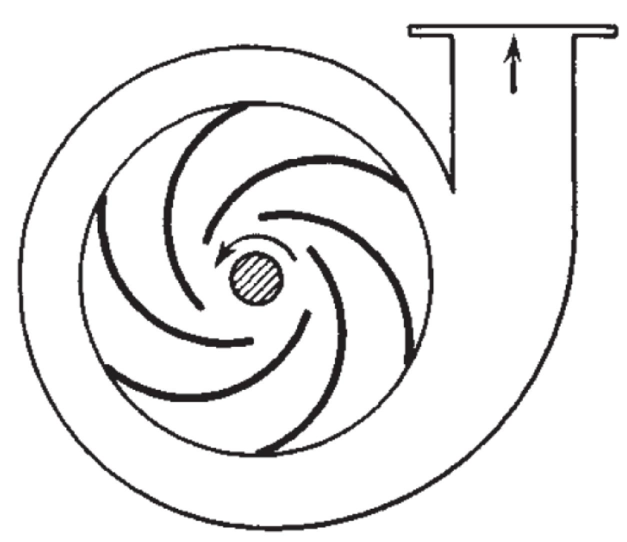


Figure 1 – Schematic of Centrifugal Pump Design

The performance characteristics of a pump are evaluated experimentally by varying its operating conditions in a controlled manner. By keeping a pump's impeller speed fixed and varying its flow rate, the pressure head, power requirements, and efficiency can be calculated. When this is done over a pump's entire operating range, a combined plot can be produced with the data, known as a "Pump Characteristic Curve." This curve is important because it can be used to appropriately select and size a pump for the most efficient operation in a process.

Experimental Setup

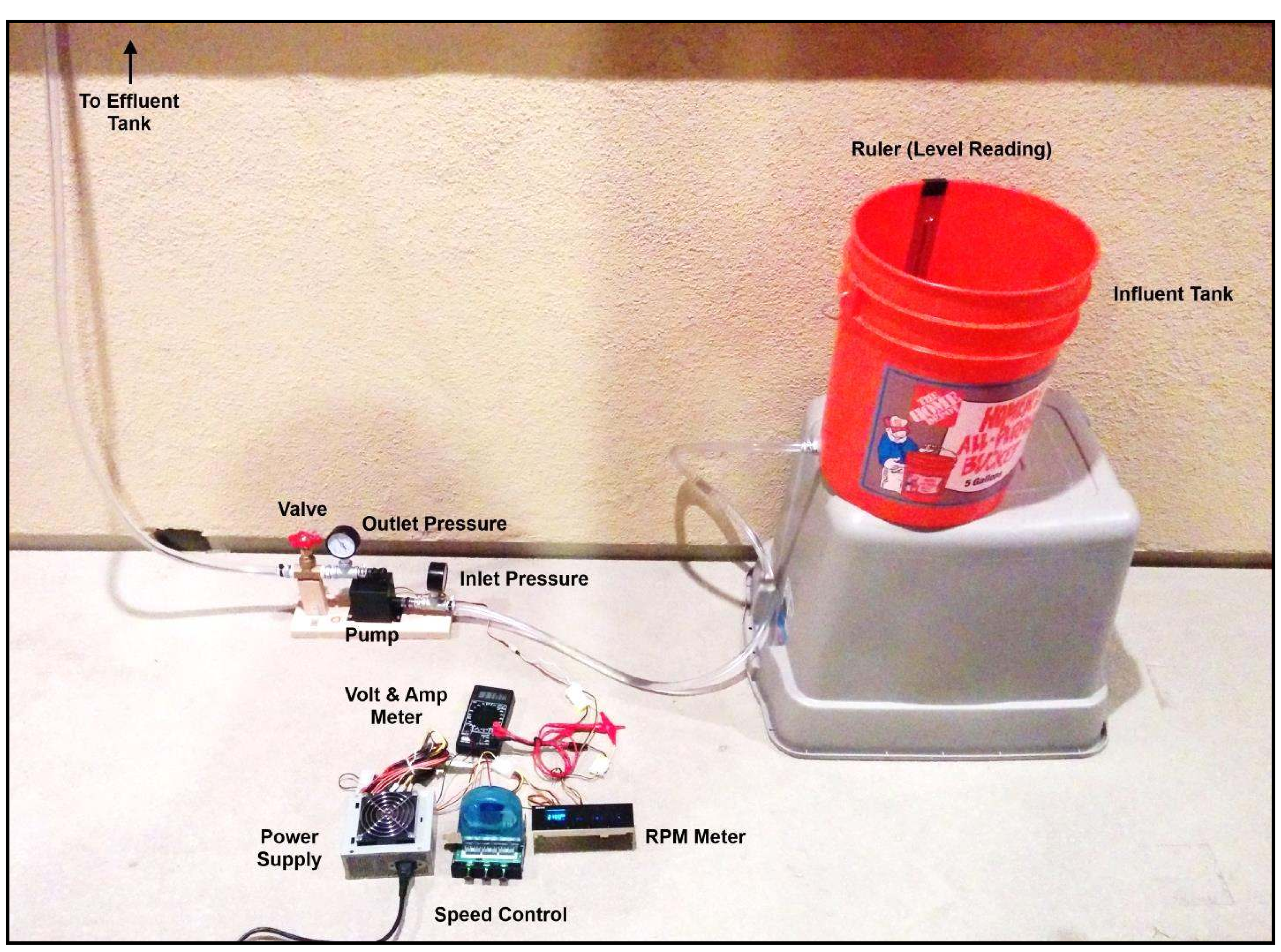


Figure 2 – Experimental Setup

Controlled Variables:

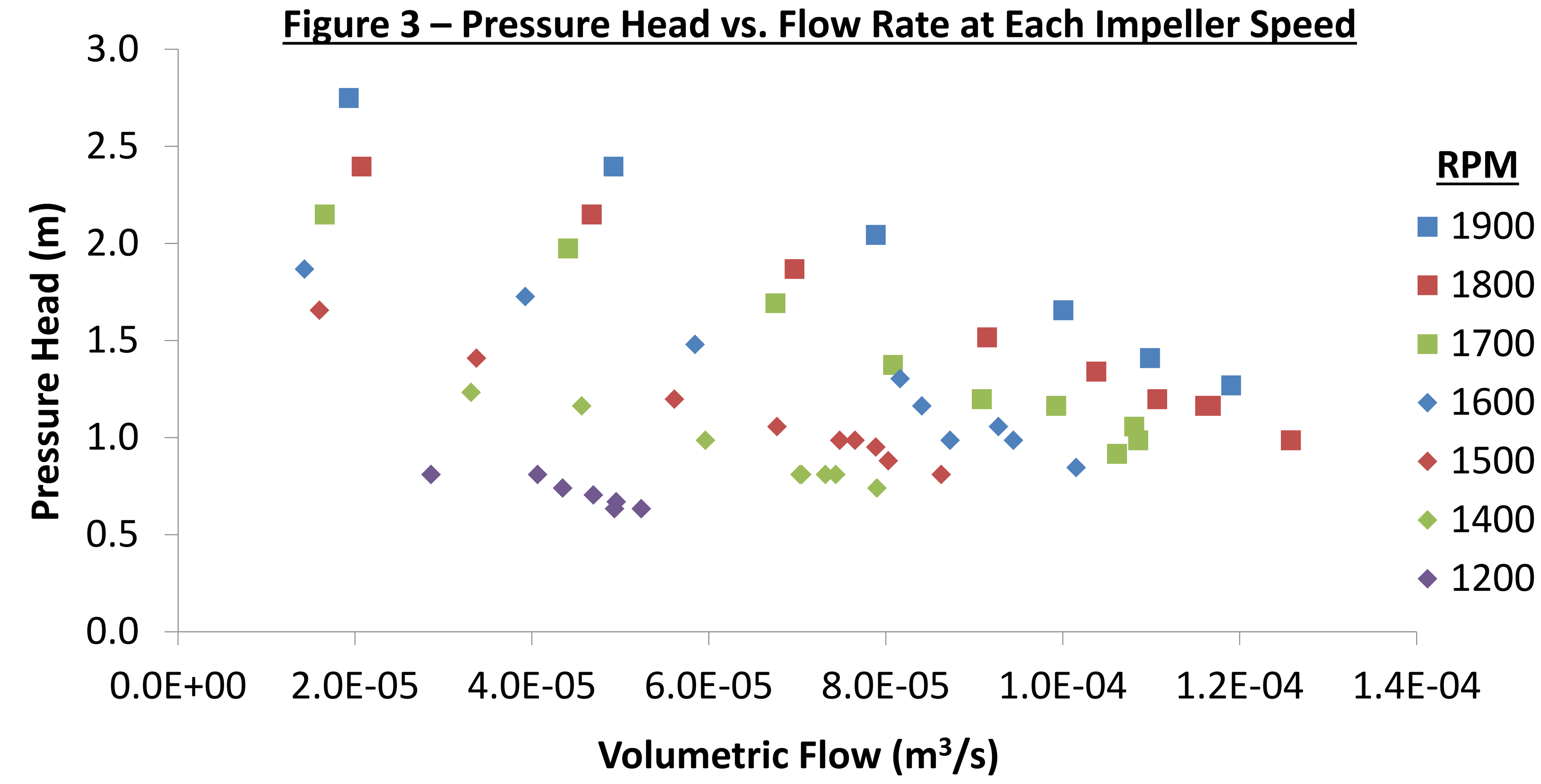
- Impeller speed from 1200 RPM to 1900 RPM
- Valve position from fully open to nearly closed

Measured Variables:

- Volumetric flow rate from tank height and stopwatch
- Pressure rise from pressure gauges
- Power required from volt and amp meter
- Power delivered from pressure rise and flow rate
- Pump efficiency from power delivered / power required

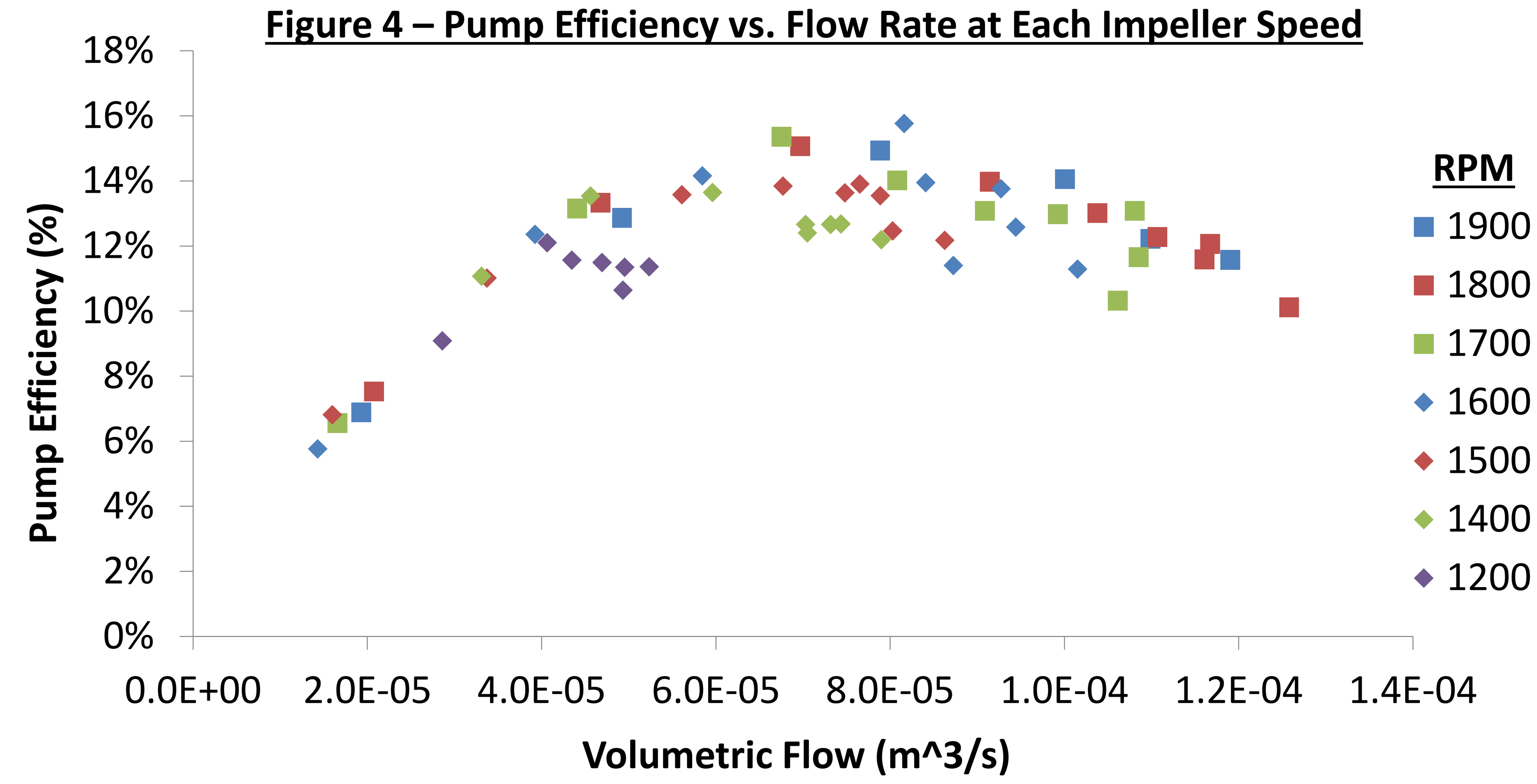
Results

Figure 3 – Pressure Head vs. Flow Rate at Each Impeller Speed



- Pressure head and flow rate were inversely related, as expected
- Increasing the pump's impeller speed increased both pressure and flow rate
- Maximum pressure rise was determined to be 2.75 meters
- Maximum flow rate was determined to be 1.26×10^{-4} m^3/s

Figure 4 – Pump Efficiency vs. Flow Rate at Each Impeller Speed



- Efficiency exhibited parabolic behavior, as expected
- Power required by motor continuously increased with flow rate
- Power delivered to fluid first increased, then leveled off at maximum flow rate
- Maximum efficiency was determined to be 16%, typical of small pumps

Conclusions

- The characteristics of the pump were evaluated over its entire operating range
- The pump behaved as expected for its type (small, high flow, and low pressure)
- Maximum flow, pressure, and efficiency were determined to be 1.26×10^{-4} m^3/s, 2.75 m, and 16%, respectively

Future Considerations:

- Find a more precise method of measuring pump speed (better than 25 RPM increments as with the current meter)
- Find a more reliable method of measuring volumetric flow rate that is not subject to reaction time (as timing with a stopwatch and reading a ruler is)

References

1. "Centrifugal Pumps." *Perry's Chemical Engineers' Handbook, 7th ed.* Section 10-24, Pg. 895.