Pressure Drop Through Tube Bundles

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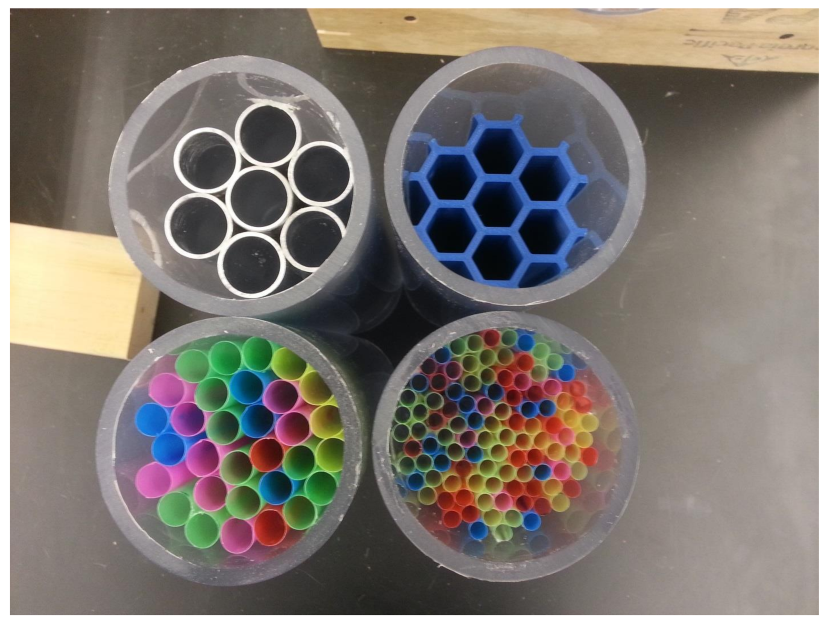
Introduction

Tube Bundles are frequently used in the chemical industry. They are most commonly used as either heat exchangers or flow straighteners. They are essentially a large bundle of equal diameter pipes bound together and often enclosed within one larger diameter pipe.



The tube bundles we built and tested

A test section was built for Calvin's wind tunnel to study the effects that different tube bundles have on the flow of air through a section of pipe.

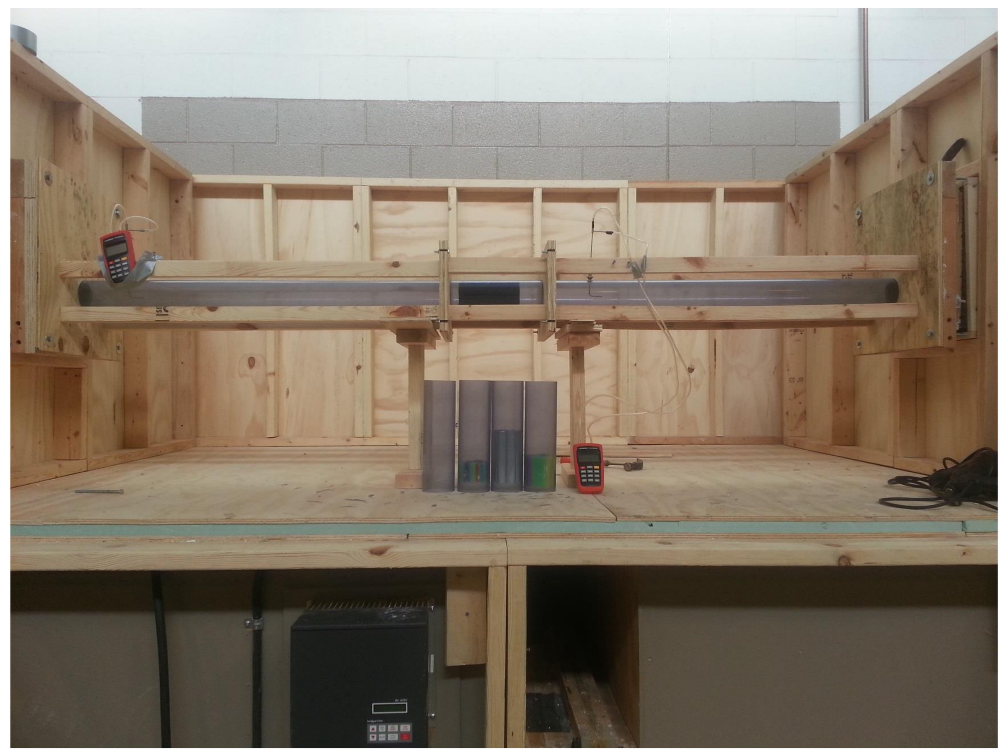
Objectives

- To observe and analyze the drop in static air pressure created by a tube bundle
- Compare the differences in pressure drop associated with different designs and sizes of tube bundles
- Use the values for pressure drop to calculate work lost from the flow along the length of the test section
- Calculate the work cost associated with each tube bundle design tested

Methods

The wind tunnel test section was 8 ft. long. It consisted of two 3 ½ ft. lengths of clear, 3.06 in. I.D. PVC pipe surrounded and held in place by a wooden frame. Each of the 3 ½ ft. sections were mounted to either end of the wind tunnel opening. In between them was a 1 ft. section that was able to be easily removed to allow for different tube bundles to be inserted into the PVC pipe.

Two pitot tubes were inserted into the PVC pipe: one before the tube bundle and one after. The pitot tubes were each connected to a digital manometer that measured both static and total air pressure at each point.



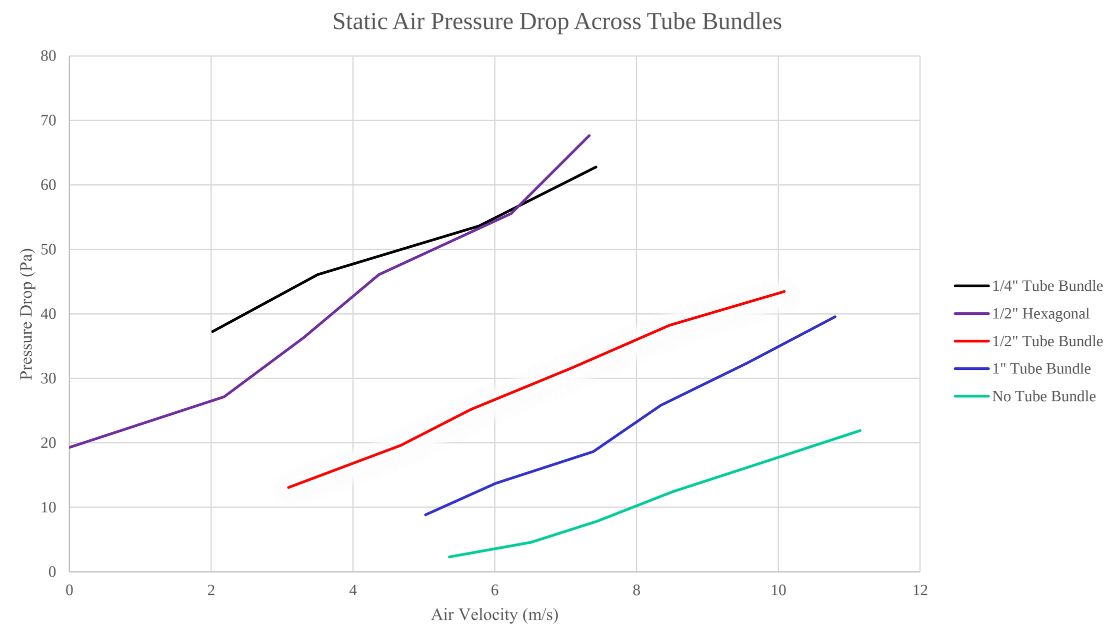
Our test section installed in the wind tunnel

For each tube bundle design, and an empty section of pipe for control, the wind tunnel was operated at 50%, 60%, 70%, 80%, 90%, and 100% of its maximum output. This correlated to air speeds inside the PVC pipe between 5 and 11 m/s.

At each output level, the static and total air pressure were recorded multiple times at each pitot tube location. The atmospheric pressure, temperature, and humidity were also recorded prior to each test with a different tube bundle.

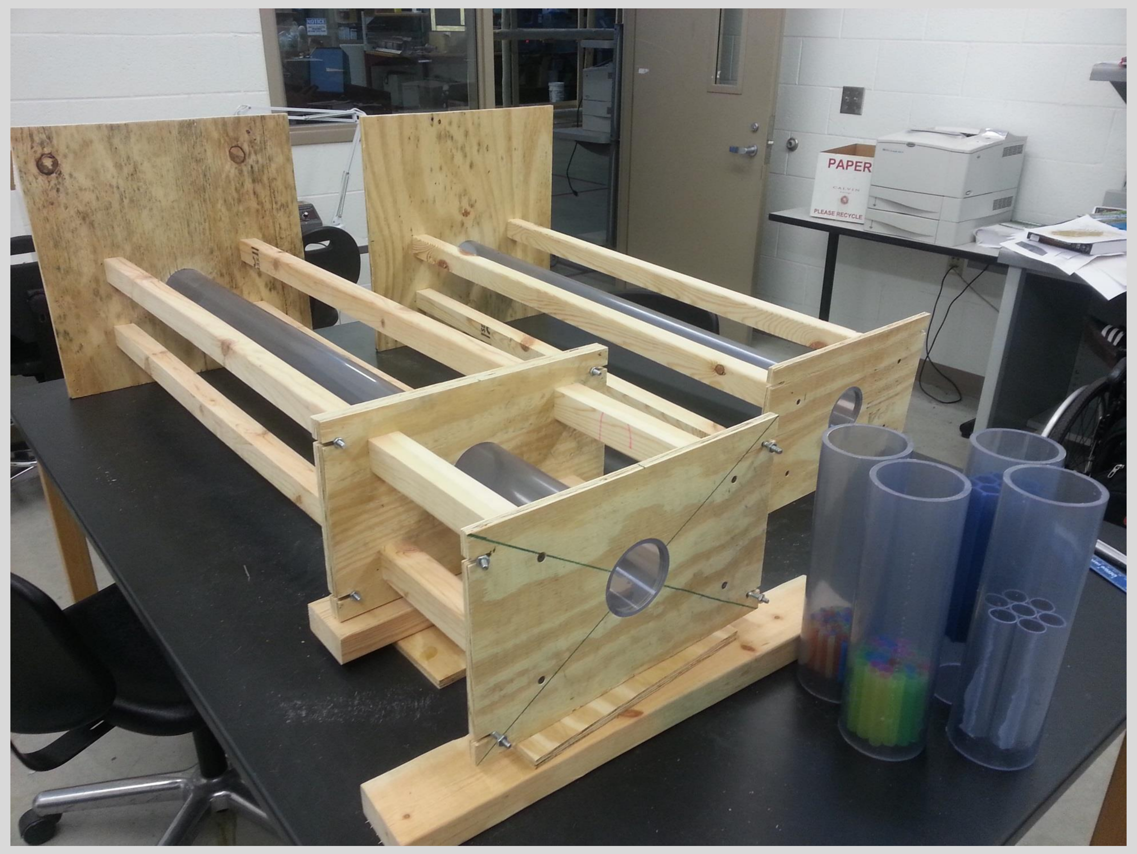
Results

Tube bundles constructed with smaller diameter tubing produced a larger drop in static air pressure along the pipe.



This is due to the fact that smaller diameter tube bundles have a much larger surface area that air must flow over and therefore generate more resistance to the flow of air than larger diameter tube bundles. Smaller diameter tube bundles also have a larger cross sectional area, blocking more of the airflow than a larger diameter tube bundle would.

It was also found that there was a higher work cost associated with smaller diameter tube bundles. This is a result of the smaller diameter tube bundles producing a larger pressure drop.



The unassembled test section

Conclusions

The decrease in static air pressure and work lost in the flow of air through a pipe are inversely related to the diameter of the tubes used in the tube bundle and directly related to the cross sectional area of the tube bundle.

While the tests we conducted were done with air, the results can be applied to the flow of any Newtonian fluid, such as water. For industries seeking to use tube bundles as flow straighteners, it would be very important to consider these effects analyzed in this study.

References

Çengel, Yunus A., Robert H. Turner, and John M. Cimbala. *Fundamentals of Thermal-Fluid Sciences*. 3rd ed. Boston: McGraw Hill Higher Education, 2008.