UNIT OPERATIONS LABORATORY 1

PBL LAB: PRESSURE DROP IN BRAZED PLATE HEAT EXCHANGER

ChEn 475 – Knotts

Background and Objectives

Our company is considering changing many of our shell and tube heat exchangers over to plate and frame heat exchangers in low-flow applications (less than 50 gpm.) Plate and frame heat exchangers cost a fraction of what shell and tube heat exchangers cost, and the design team can see no reason from a heat transfer perspective why one is more advantageous than the other. Before proceeding further, we need to know the pressure drop characteristics of the plate and frame heat exchangers. While a large amount of literature, including correlations, exist that describes the pressure drop in shell and tube heat exchangers, very little work has been published on this subject for plate and frame heat exchangers. Such information is needed to determine if current pumps in our processes can be used with the plate and frame heat exchangers and when designing the pumping systems of future applications.

We have acquired four different plate and frame heat exchangers for you to test. They are constructed of 304 stainless steel with copper brazing, and each is rated for up to 17.6 gal/min of water with temperatures ranging from -105 to +250 °C. They are rated for pressures up to 10 bar pressure but have been tested at twice that pressure. Two of the heat exchangers have approximately the same total heat transfer area but different dimensions. The other has twice the heat transfer area. The exact heat transfer areas are labelled on the exchangers. All connections are ¾" male NPT treads.

Your task is to measure the pressure drop for the four different plate and frame heat exchangers that we have acquired and report your findings. Accomplishing this task will include building and validating an experimental apparatus, measuring the losses, and delivering a final report. Multiple pieces of equipment are available for your use as outlined below. You will not (cannot) use all of them and are free to design the system however you see fit to achieve the design conditions given above. But note that part of your grade for this project is based on the quality of the design and your execution.

Preparation for Construction

Before beginning any assembly, please deliver a proposal to me outlining your approach. Only one proposal per team is needed. This email should have one or two paragraphs and one or two attached slides that explain your design plan and the rationale (calculations) for your approach. Your email should include an expected range of flowrates that you can access with your system with an appropriate figure. I also want an email update on your progress about half way through the build process. (See the class schedule for the exact due date.)

On the first lab day, after acquainting yourself with the purpose of the lab and the tools you have to accomplish the design goals, you should complete the *Labview Assignment*. Labview is the system you will use to control your apparatus. This assignment will get you started on learning this tool. You may work as a team, but everyone on the team needs to write up a separate assignment to turn in.

Beginning either on the second or third day of the lab, after the Labview assignment, each member of the team will complete the *Pipes, Fittings, and Instrumentation Check-Off Assignment*. The purpose of this is to train you on how to physically construct an apparatus in the proper way. Part of the grade for the PBL lab covers the quality of your design which includes complying with the skills and concepts taught in this training.

Construction and Safety

You may begin constructing your apparatus once you have 1) turned in your proposal, 2) turned in a completed Labview Assignment, 3) turned in a completed *Pipes, Fittings, and Instrumentation Check-Off Assignment*, and 4) receiving approval from the instructor. However, ***before*** powering on or plugging in any part of your apparatus, including the Labview modules, you must explain the safety procedures you have in place to prevent harm to equipment or person including some form of lock-out/tag-out. Again, *make sure your wiring is checked off with either Mike or John before powering on any part of the system.* You will probably do this in stages because you will want to supply power to the Labview modules before powering on the pump. But make sure you fully understand where electrocution can take place for all parts of your system.

Due Date for Apparatus Demonstration and Evaluation

You have until the last PBL lab day to demonstrate that your apparatus fulfills the design requirements. To do this, you will simply show me and a lab manager that it works. At this time, we will also evaluate the quality of your design.

Final Report Requirements

Your final report should give the final results and validation of your project. This is an individual report. It is here that you show the "numbers" that answer the design problem. It should contain a description of the apparatus and quantitatively demonstrate that you achieved the design conditions. It should also address that you did not over specify the system so that the capital and operating costs are minimized.

Logistical and Equipment Considerations

Design Space

You will build the entire system on one of the wheeled, T-slot frames provided. Place this frame in one of the two areas, marked by yellow caution tape, in the middle of the projects lab.

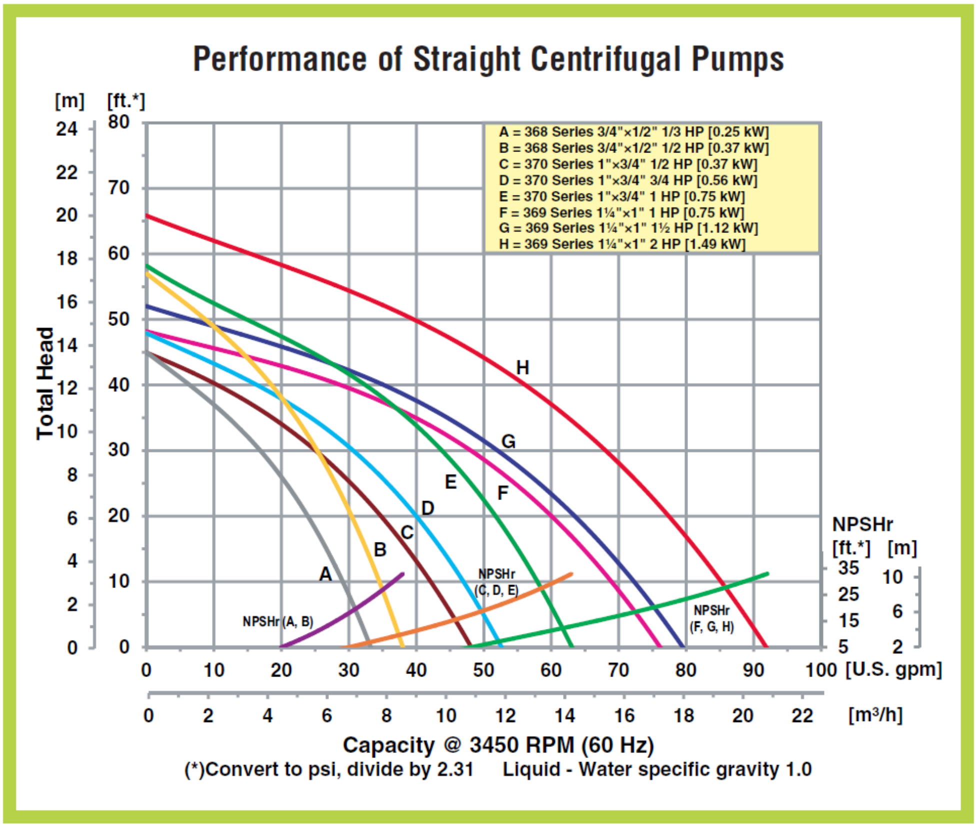
Measurement Options

Two types of devices are available to measure pressures: Bourdon pressure gauges and pressure transducers. The transducers have been obtained from Omega (see website for calibration). Precision turbine flow meters are also available, but these are not the only way to measure flowrate. The pressure transducers and flow meters can be controlled using Labview. These don't have to be used, but are provided if you feel they are needed to achieve your aims.

Regardless of the measurement devices you use, you should be aware of the accuracy of each and factor this into your design and execution (and subsequent grade). Note also that the pressure transducers are expensive and can be destroyed if subjected to a differential pressure that is larger than the stated rating on the device. Also note that stainless steel flanges have been placed around the transducers and flow meters to preserve the threads and reduce replacement costs of these expensive pieces of equipment.

Pump Options

Three different pumps are available: 1/3 hp, 1/2 hp, and 1 hp. The pump performance curves for these is found below. For your convenience, an Excel file named "`PBL Pump Performance Curves and Data.xlsx`" is available on the website (under the hints for the PBL labs) that contains the numerical data from these plots. (Note: stainless steel flanges have been placed on these pieces of "costly" equipment to preserve the threads.)



Pipe and Fittings Options

Schedule 40, galvanized pipe is available in ½", ¾", 1", and 1¼" inch in lengths of 1', 3', and 5'. Jack stands fitted with t-slot are also available so that you can position pipe and equipment in desired locations and arrangements. Various brass and galvanized steel fittings are also available.

Ideas to Think About and/or Investigate

As you construct your experimental apparatus to answer the design problem, you are going to have to make several decisions. You are also going to answer several questions as you analyze or design the system. These include (but are not limited to) the following:

1. What size pump do you need?
2. How will you change flow rate?
3. What length(s) of pipe do you need?

4. What frictional losses do I need to take into account?
5. Does the length of the system affect your ability to take accurate measurements?
6. What height change is needed or demanded by the design constraints?
7. How will pipe size be determined or influence other design choices?
8. What will the Reynold's number be? How does it affect pressure drop?
9. How do pump size and pipe diameter affect the pressure drop?
10. How does heat exchanger shape and surface area correlate with pressure drop?
11. What applications exist for determining the pressure drop across a unit?

Deliverables

1. Proposal email (Team; turn in to Dr. Knotts)
2. Labview assignment (Individual; turn in to the TA)
3. Pipe fitting assignment (Individual; turn in to TA)
4. Quality of design (Team; Dr. Knotts will do, nothing to turn in)
5. Final written report (Individual; turn in to Dr. Knotts)
6. Leadership report (Individual; turn in to Dr. Knotts)
7. Lab notebook (Team, turn in to TA)