MEC 722 Assignment #1
Fall 2015
Due Monday, October 5 @ 4:00PM

A jacketed reactor is a vessel that consists of an inner tank, and an outer enclosure. Process fluids that need to be heated or cooled are contained in the inner tank, and the heating or cooling fluid is circulated through the jacket. Heat transfer between the two fluids occurs through the inner tank wall. Often, an agitator is used to mix the tank contents while processing occurs. Literally thousands of products are made in jacketed reactors, ranging from soup to pharmaceuticals. Many fluids can be used for heating or cooling. The most common fluids used are steam, hot or cold water, thermal oils, glycol etc.

Schematic representation of a jacketed reactor. Source: http://upload.wikimedia.org/wikipedia/commons/thumb/5/5c/Batch_reactor.2.jpg/800px-Batch_reactor.2.jpg

Your company has recently ordered 3 jacketed reactors for producing a pharmaceutical product. The reactors need to be heated using hot water at 80°C, supplied by one central heater as shown on the process flow diagram. Some of the salient technical points are as follows:

1) Each reactor must have its own automatic temperature control loop. Temperature control can be accomplished by monitoring the process temperature in the tank, and varying the flow rate of 80°C water through the jacket. If the process temperature drops below set point, the system should respond by increasing the water flow rate.

2) The maximum allowable water flow rate through the jacket is 50 USGPM. The maximum expected temperature drop at maximum water flow is 15°C. (ie maximum heat load per reactor occurs when the water flow rate is 50 USGPM, with water entering the jacket at 80°C and leaving at 65°C)

3) The water pressure drop through the jacket is 5 PSI at the maximum flow rate of 60 USGPM.

4) You may assume that the maximum pressure drop through the heater is 5 PSI. You may treat the heater as a "black box" that outputs hot water at 80°C in response to a control signal from a controller.

5) Make the following assumptions about pipe runs:

- The main water supply and return lines are 30m long each, and each run has 4 90° elbows.
- Each line to/from the main supply/return lines to the reactors is 20m long, and has 3 90° elbows.

All pipe will be Sch 40 steel pipe.

Questions:

1) Determine the heater size (in kW) required for this service if the heater is to be sized so that it is large enough to handle all three reactors when they are at full load.

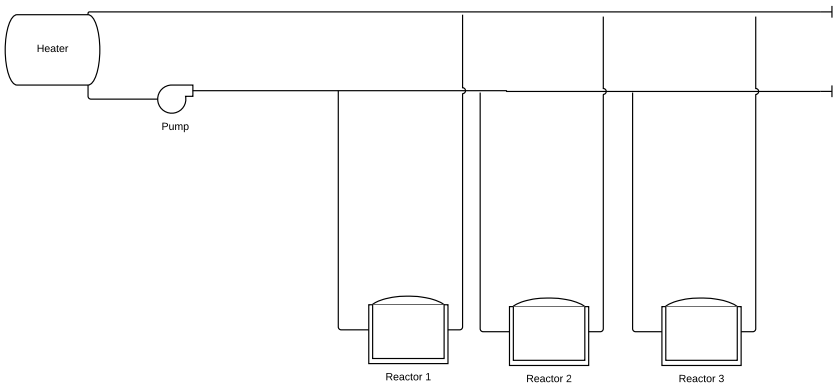
2) Prepare a P&ID showing all necessary valves, controls and instrumentation for this system. You **MUST** use ISA standard symbols. Include tag numbers that reference the Bill of Materials (ie Tag #1 refers to item 1 on the BOM etc).

3) Based on your P&ID, determine the appropriate pipe sizes for the system. There should be two different pipe sizes: one for the main supply and return lines, and another for the lines connecting the reactors to the main supply/returns. Refer to Chapter 6 in your fluids text (F.M. White, "Fluid Mechanics") or any other

appropriate reference for K-factors for the fittings in your system. For valves pressure loss calculations, use manufacturer's data for appropriate Cv's.
NOTE: You must use Cv's for valve pressure losses, **not** k's as found in your Fluids text (these are inaccurate, and most North American valve manufacturers do not publish k values). You can find some manufacturer's data on the course web site under Information>Reference Material>Velan Valve Catalog.

4) Determine the required pump head and flow rate for your design.

Note: Communication skills are an important element of this assignment. Your assignment should be presented in a logical, coherent format as though you were presenting it to senior management. There should be an introduction that explains what the problem is, a calculation section presenting all calculations made, a Drawings section presenting your P&ID, and other sections you deem necessary. All calculations and drawings should be accompanied by text explaining what they represent, what assumptions are made etc.



Process Flow Diagram for Jacketed Reactor System

Grading Rubric for Assignment 1
MEC 722
Thermal Systems Design

Qualities and Criteria	Poor 0 - 5	Acceptable 6 - 8	Excellent 9 - 10
Format/Layout • Presentation of the text • Structure of text **(Weight 20%)**	Poor presentation Disorganized layout Lack of care in preparation	Generally good presentation	Professional-looking presentation Obvious care and attention to detail
Grade (on 10):			
Content/Information • All elements of the topic addressed • Information technically sound • Information based on careful research • Coherence of information **(Weight 40%)**	Content overly light technically Factual errors Obvious misunderstanding of topic details Lack of coherence	Generally factually correct Appropriate technical level Adequate research Generally coherent	Topic well covered Technically in-depth Thoroughly researched Well structured and easy to follow
Grade (on 10):			
Quality of Writing • Clarity of sentences and paragraphs • No errors in spelling and grammar • Organization and coherence of ideas **(Weight 15%)**	Numerous spelling errors and/or typos Poor grammar Lack of organization	Generally well written Few typos or grammatical errors Reasonably organized	Very well written Few or no typos/grammatical errors Coherent and well organized
Grade (on 10):			
Drawings • Appropriate drawings produced • Drawings properly drafted • Correct/appropriate information present **(Weight 20%)**	Drawings missing Numerous drafting errors Critical information missing Messy/poor organization	All appropriate drawings present Generally correctly drawn with few drafting errors Reasonably laid out Only minor omissions	Very well drafted/organized No drafting errors All required information present
Grade (on 10):			
References • References appropriate to the topic • Proper citation format used • References used correctly to support text **(Weight 5%)**	Few references References at an inappropriate level Improper citation format References not used properly to support text	References appropriate for the topic Citation format correct References generally well used to support text	Thoroughly referenced at the appropriate level Correct citation format used Excellent use of citations to support text/calculations
Grade (on 10):			

Overall Grade: 0.20 x _____ + 0.40 x _____+ 0.15 x _____ + 0.20 x _____+ 0.05 x _____ =_____/ 10
Graded by: _____