Design Problem 1 – Pump and Piping Design

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Objectives

The objectives of Design Problem 1 are to: (1) update the cost index in CHEMCAD, (2) use CHEMCAD to perform an optimized design and pricing of a section of pipeline, and (3) determine the purchased price and power requirements for a pump.

Problem Statement

Your assignment is to use CHEMCAD to design the piping and pump to deliver feed liquid to a distillation process. The feed temperature, pressure, and component flow rates are given in Table 1, and you will determine the size and cost of the pump and pipeline needed to deliver the feed to the column. You will also determine the size and cost of fittings and valves, the cost of paint for the pipe, and the energy requirements for one year of operation. Finally, this type of system must be *optimized* for peak economic efficiency, and you will discuss why your solution is considered to be optimized. Your design will be subject to the constraints and specifications described below.

Table 1. Feed Component Flow Rates (298 K and 202.650 kPa)

Component	Feed Rate, lb-mol/h
Toluene	91.50
Naphthalene	299.81
Biphenyl	3156.56
Diphenylenemethane (Fluorene)	192.94
Phenanthrene	144.19
M-Terphenyl	359.81
Total	4244.81

Constraints and Additional Information

- You are designing the pump and the pipe connecting the pump to the column. You will *not* be designing the distillation column or column internals (trays, shell, condenser, reboiler). This has already been designed by another group.
- Pump constraints and specs:
  - The pump and motor costs must be calculated in CHEMCAD. The pump is centrifugal, one stage, 3550 rpm vertical split casing (VSC), cast steel, and explosion proof, and the pump motor is 1200 rpm, and installed costs are 2.8 times the purchased equipment cost.
  - CHEMCAD cost information must be updated to January 2024 by entering the current Chemical Engineering Plant Cost Indices. Values can be viewed in “Tools,” then “Edit Cost Index.”

- Energy cost based on one year of operation (365d=1yr) at $0.0646 per kWh and the pump is 79% efficient.
  (energy costs found at https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a)

- Piping constraints and specs:
  - Pipe, valve, and fitting costs cannot be calculated in CHEMCAD. Pipe costs can be found in the PTW textbook. Any cost data taken from the textbook is referenced to January 2002.
  - Fittings costs are not in the 2002 edition of the textbook. They can be found in the "1979 Pipe & Fitting Prices" document found in your SharePoint (Fig. 13-4, PTW, 3rd ed., p. 529). This data is referenced to January 1979.
  - Installed costs are 2.8 times the purchased equipment cost.
  - The pipe diameter is determined in CHEMCAD. Fluid flow in the pipeline is single-phase, and the pipe sizing option in CHEMCAD is "1 Design, single-phase flow."
  - All pipe and fittings are Sch. 40 welded commercial (carbon) steel and must be painted.
  - The length of the pipeline is 153 feet with a net elevation change of 19 feet.
  - The pipeline has 12 90° standard elbows, two gate valves, three globe valves, and one sudden expansion where the fluid emerges into the column. The diameter ratio for the expansion can be taken as 0.001.
  - The feed must enter the column at **298 K and 353.5 kPa**.

Submission Requirements

1. Download, complete and upload the CHEMCAD template found in Canvas.

2. Download, complete and upload the Excel template found in Canvas, including:

   a. Diameter, purchased and installed costs in January 2024 for pipe, elbows, valves, and paint.

   c. Purchased and installed cost of pump and motor in January 2024.

   d. Pump NPSH, power, energy, and energy cost for 1 year of operation.

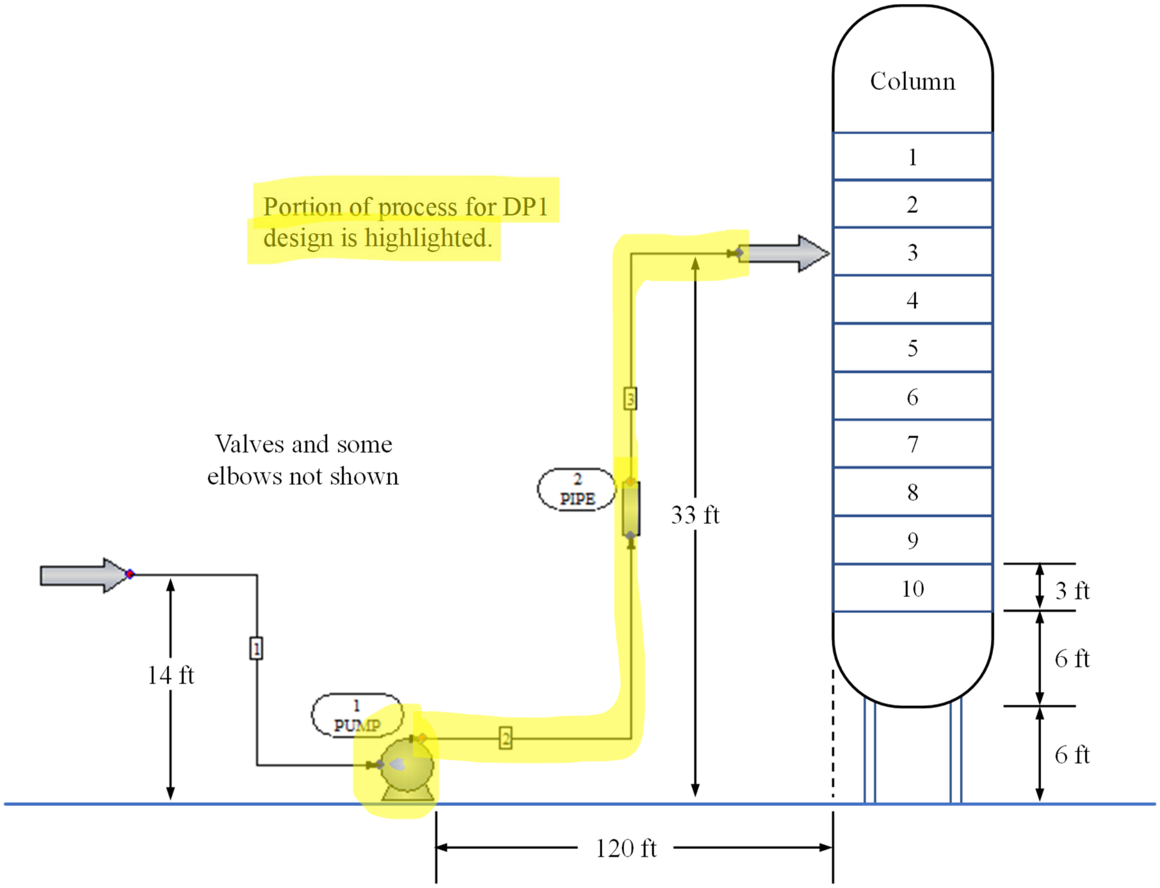
   d. Total cost of installed equipment and energy for one year of operation.

   e. Print the bordered areas from the Excel template as a pdf, attach a cover sheet, and submit the combined pdf to Canvas.

3. How do you know the design has been *optimized*? Answer this question in the space provided in Excel. Perform additional calculations with Excel and CHEMCAD to prove your argument.

4. All three electronic files (CHEMCAD, Excel, and PDF) must be uploaded to Canvas.

Addendum – Process Sketch



Vertical split-case pump (VSC), https://www.statesupply.com/bell-and-gossett/pump/series-vsx. Casing split is perpendicular to motor shaft axis.

Horizontal split-case pump (HSC), https://www.ruhrpumpen.com/en/products/between-bearing-pumps/hsc-pump. Casing split is parallel to motor shaft axis.