Design Problem 1 – Pump and Piping Design

1. Objectives
2. Problem statement.
3. Constraints and additional information.
4. Submission requirements.

Objectives

The objectives of Design Problem 1 are: (1) to use CHEMCAD to perform an optimized design and pricing of a section of pipeline, (2) to update the cost index in CHEMCAD, 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 process. The feed liquid temperature, pressure, and component flow rates are shown in Table 1 below, and this mixture is to be fed to a multi-component distillation column. That is, you will determine the size and cost of the pipeline needed to connect the feed pump to the column. You will also determine the power and price of the feed pump, 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 additional information 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 will *not* be designing the distillation column or column internals (trays, shell, condenser, reboiler). This has already been designed by another group.
- You are designing the pump and the pipe connecting the pump to the column.
- Additional piping constraints and specs:
  - Pipe sizing option in CHEMCAD is “1 Design, single-phase flow.”
  - All pipe and fittings are Sch. 40 welded commercial (carbon) steel.
  - The length of the pipeline is 153 feet with a net elevation change of 19 feet.
  - The pipe material is from commercial steel and must be painted.

- The pipeline has twelve 90° standard elbows, two gate valves, three globe valves, and one sudden expansion where the fluid emerges into the distillation 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**.
- Pipe and valve costs cannot be calculated in CHEMCAD. Pipe costs can be found in the PTW textbook or on the PTW web site. Any cost data taken from the textbook is referenced to 2002.
- Fittings costs are not in CHEMCAD and are not in 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 1979.
- Installed costs are 2.8 times the purchased equipment cost.

- Additional pump constraints and specs:
  - The pump and motor costs are calculated in CHEMCAD. The pump is centrifugal, cast steel and explosion proof, 1200 rpm, and is 79% efficient.
  - CHEMCAD cost information must be updated by entering the current Chemical Engineering Plant Cost Indices. Values can be viewed in "Tools," then "Edit Cost Index."
  - Installed costs are 2.8 times the purchased equipment cost.
  - Energy cost is based on one year of operation (365d=1yr) at $0.0646 per kWh. (https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a)

Submission Requirements

1. 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.
2. Complete and upload the CHEMCAD template found in Canvas.
3. Discuss how the design has been *optimized*. Answer this question in the space provided in Excel.
4. All three electronic files (CHEMCAD, Excel, and PDF) must be uploaded to Canvas.

Addendum – Process Sketch