APPROVED SOLUTION

CADET _____ SECTION _____TIME OF DEPARTURE _____

DEPARTMENT OF CHEMISTRY & LIFE SCIENCE

CH402, AY2024-2025
WRITTEN PARTIAL REVIEW I
55 Minutes, B-Hour
10 February 2025

TEXT: Peters, Timmerhaus & West
SCOPE: CHAPTERS: 12, 14

References Permitted: Open note and open book; Mathematica; Excel; CHEMCAD.

INSTRUCTIONS

1. You will have 55 minutes for the exam.
2. Do not mark this exam or open it until "begin work" is given.
3. There are 3 problems on 3 pages in this exam (not including the cover page).
4. Write your name on the top of each sheet.
5. Solve the problems in the space provided or in CHEMCAD.
6. Show all work to receive full credit.
7. Save all work and save it frequently.
8. Upload you CHEMCAD file to CANVAS.

(TOTAL WEIGHT: 200 POINTS)

DO NOT WRITE IN THIS SPACE

PROBLEM	VALUE	CUT
A	80	
B	60	
C	60	
TOTAL CUT		
GRADE	200	

Cadet: APPROVED SOLUTION

Problem:	Weight:
A	80

A TEMA-R type AEL carbon steel shell-and-tube heat exchanger is being considered for a process in which a stream of benzene at 405.3 kPa must be heated from 20°C to 100°C. A hot stream of 1.5 kg/s of nitrogen at 380°C and 1020 kPa is available for the process and will enter the exchanger on the shell side and emerge at 200°C.

- The exchanger is constructed from ½-inch Sch 40 tubes.
- The outside diameter of the tubes is 0.0213 m with a wall thickness of 0.00277 m.
- The tube pitch of 0.0267 m
- The tubesheet thickness equal to the tube outside diameter.
- Assume the fouling factors are zero.
- All other design constraints and geometric details are the CHEMCAD defaults.
- SRK should be used for K-value and enthalpy models.

Under these conditions, determine the flow rate of the benzene, the length and number of tubes, the inside diameter of the shell, and the purchased cost of the exchanger in February 2025. Are vibrations detected in this heat exchanger?

SOLUTION:

Benzene flow rate, kg/s	2.0874 //ANS
Tube length, m	3.05 //ANS
Number of tubes	35 //ANS
Shell inside diameter, m	0.20 //ANS
Purchased Cost in February 2025, $	$7,054 //ANS
Vibrations detected? (Y/N)	Yes //ANS

Problem is solved in CHEMCAD.

Problem:	Weight:
B	60

Assuming the benzene leaves the exchanger in Problem A at a flow rate of 2.1 kg/s, a pressure of 402 kPa, and a temperature of 107°C, determine the purchased cost of a centrifugal pump in February 2025 that will pressurize the benzene to 430.27 kPa. The pump is centrifugal, one stage, 3550 rpm, VSC, cast iron, and with an open drip-proof 3600 RPM motor.

SOLUTION:

Purchased Cost in February 2025, $	$8,013 //ANS

Problem is solved in CHEMCAD.

Problem:	Weight:
C	60

Determine the nominal diameter and purchased cost of a section of carbon (commercial) steel pipe that will connect the outlet of the pump in problem B to a storage tank at 405.3 kPa. The benzene at the inlet of the pipe is flowing at 2.1 kg/s, a pressure of 430.27 kPa, and a temperature of 107°C. The pipe is 100-m carbon (commercial) steel welded Sch 40 with four standard 90° elbows and no elevation change. Determine the cost of the piping only. Do not include the cost of the elbows.

SOLUTION:

Nominal diameter, inches	2 //ANS
Purchased Cost in February 2025, $	$1,572 //ANS

The diameter is determined in CHEMCAD, but CHEMCAD will not calculate pipe costs.

Cost is from Figure 12-4 at 2 inches, adjusted with the CEPCI for pipes for years 2002 and 2025:

$$\frac{\$6.6}{\text{m}} \cdot 100\text{m} \cdot \frac{\text{CEPCI}_{2025}}{\text{CEPCI}_{2022}} = \frac{\$6.6}{\text{m}} \cdot 100\text{m} \cdot \frac{1324.2}{555.8} = \$1,572$$

APPROVED SOLUTION

CADET _____ SECTION _____TIME OF DEPARTURE _____

DEPARTMENT OF CHEMISTRY & LIFE SCIENCE

CH402, AY2024-2025
WRITTEN PARTIAL REVIEW I
55 Minutes, D-Hour
10 February 2025

TEXT: Peters, Timmerhaus & West
SCOPE: CHAPTERS: 12, 14

References Permitted: Open note and open book; Mathematica; Excel; CHEMCAD.

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(TOTAL WEIGHT: 200 POINTS)

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PROBLEM	VALUE	CUT
A	80	
B	60	
C	60	
TOTAL CUT		
GRADE	200	

Cadet: APPROVED SOLUTION

Problem:	Weight:
A	80

A TEMA-R type AEL carbon steel shell-and-tube heat exchanger is being considered for a process in which a stream of toluene at 303.98 kPa must be heated from 20°C to 100°C. A hot stream of 4.0 kg/s of n-hexane at 250°C and 202.65 kPa is available for the process and will enter the exchanger on the shell side and emerge at 100°C.

- The exchanger is constructed from ½-inch Sch 40 tubes.
- The outside diameter of the tubes is 0.0213 m with a wall thickness of 0.00277 m.
- The tube pitch of 0.0267 m
- The tubesheet thickness equal to the tube outside diameter.
- Assume the fouling factors are zero.
- All other design constraints and geometric details are the CHEMCAD defaults.
- SRK should be used for K-value and enthalpy models.

Under these conditions, determine the flow rate of the benzene, the length and number of tubes, the inside diameter of the shell, and the purchased cost of the exchanger in February 2025. Are vibrations detected in this heat exchanger?

SOLUTION:

Toluene flow rate, kg/s	9.8675 //ANS
Tube length, m	4.88 //ANS
Number of tubes	154 //ANS
Shell inside diameter, m	0.39 //ANS
Purchased Cost in February 2025, $	$20,760 //ANS
Vibrations detected (Y/N)	Yes //ANS

Problem is solved in CHEMCAD.

Problem:	Weight:
B	60

Assuming the toluene leaves the exchanger in Problem A at a flow rate of 9.9 kg/s, at a pressure of 297 kPa, and a temperature of 102°C, determine the purchased cost of a centrifugal pump in February 2025 that will pressurize the toluene to 346.15 kPa. The pump is centrifugal, one stage, 3550 rpm, VSC, cast iron, and with an open drip-proof 3600 RPM motor.

SOLUTION:

Purchased Cost in February 2025, $	$7,907 //ANS

Problem is solved in CHEMCAD.

Cadet: APPROVED SOLUTION

Problem:	Weight:
C	60

Determine the nominal diameter and purchased cost of a section of carbon (commercial) steel pipe that will connect the outlet of the pump in problem B to a storage tank at 303.98 kPa. The toluene at the inlet of the pipe is flowing at 9.9 kg/s, a pressure of 346.15 kPa, and a temperature of 102°C. The pipe is 75-m carbon (commercial) steel welded Sch 40 with six standard 90° elbows and an elevation increase of 2 m. Determine the cost of the piping only. Do not include the cost of the elbows.

SOLUTION:

Nominal diameter, inches	3.5 //ANS
Purchased Cost in February 2025, $	$2,680 //ANS

The diameter is determined in CHEMCAD, but CHEMCAD will not calculate pipe costs.

Cost is from Figure 12-4 at 2-inches, adjusted with the CEPCI for pipes for years 2002 and 2025:

$$\frac{\$15}{\text{m}} \cdot 75\text{m} \cdot \frac{\text{CEPCI}_{2025}}{\text{CEPCI}_{2022}} = \frac{\$15}{\text{m}} \cdot 75\text{m} \cdot \frac{1324.2}{555.8} = \$2,680$$

APPROVED SOLUTION

CADET _____ SECTION _____TIME OF DEPARTURE _____

DEPARTMENT OF CHEMISTRY & LIFE SCIENCE

CH402, AY2024-2025
WRITTEN PARTIAL REVIEW I
55 Minutes, Makeup
11 February 2025

TEXT: Peters, Timmerhaus & West
SCOPE: CHAPTERS: 12, 14

References Permitted: Open note and open book; Mathematica; Excel; CHEMCAD.

INSTRUCTIONS

1. You will have 55 minutes for the exam.
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PROBLEM	VALUE	CUT
A	80	
B	60	
C	60	
TOTAL CUT		
GRADE	200	

Cadet: APPROVED SOLUTION

Problem:	Weight:
A	80

A TEMA-R type AEL carbon steel countercurrent shell-and-tube heat exchanger is being considered for a process in which a stream of toluene at 405.3 kPa must be heated from 20°C to 100°C. A hot stream of 15.0 kg/s of Dowtherm G at 200°C and 202.65 kPa is available for the process, entering the exchanger on the shell side and emerging at 100°C.

- The exchanger is constructed from ½-inch Sch 40 tubes.
- The outside diameter of the tubes is 0.0213 m with a wall thickness of 0.00277 m.
- The tube pitch of 0.0267 m
- The tubesheet thickness equal to the tube outside diameter.
- Assume the fouling factors are zero.
- All other design constraints and geometric details are the CHEMCAD defaults, but you may need to increase the upper limits on the tube length and shell diameter.
- SRK should be used for K-value and enthalpy models.

Under these conditions, determine the flow rate of the toluene, the length and number of tubes, the inside diameter of the shell, and the purchased cost of the exchanger in February 2025. Are vibrations detected in this heat exchanger?

SOLUTION:

Toluene flow rate, kg/s	18.9216 //ANS
Tube length, m	6.10 //ANS
Number of tubes	200 //ANS
Shell inside diameter, m	0.44 //ANS
Cost in February 2025, $	$29,054 //ANS
Vibrations detected? (Y/N)	No //ANS

Problem is solved in CHEMCAD.

Problem:	Weight:
B	60

Assuming the toluene leaves the exchanger in Problem A at a flow rate of 19.0 kg/s, a pressure of 397 kPa, and a temperature of 102°C, determine the purchased cost of a centrifugal pump in February 2025 that will pressurize the toluene to 473.72 kPa. The pump is centrifugal, one stage, 3550 rpm, VSC, cast iron, and with an open drip-proof 3600 RPM motor.

SOLUTION:

Purchased Cost in February 2025, $	$9,059 //ANS

Problem is solved in CHEMCAD.

Cadet: APPROVED SOLUTION

Problem:	Weight:
C	60

Determine the nominal diameter and purchased cost of a section of carbon (commercial) steel pipe that will connect the outlet of the pump in problem B to a storage tank at 405.3 kPa. The toluene at the inlet of the pipe is flowing at 19.0 kg/s, a pressure of 473.72 kPa, and a temperature of 102°C. The pipe is 150-m carbon (commercial) steel welded Sch 40 with 12 standard 90° elbows and an elevation change of 2 m. Determine the cost of the piping only. Do not include the cost of the elbows.

SOLUTION:

Nominal diameter, inches	5 //ANS
Purchased Cost in February 2025, $	$6,790 //ANS

The diameter is determined in CHEMCAD, but CHEMCAD will not calculate pipe costs.

Cost is from Figure 12-4 at 5 inches, adjusted with the CEPCI for pipes for years 2002 and 2025:

$$\frac{\$19}{\text{m}} \cdot 150\text{m} \cdot \frac{\text{CEPCI}_{2025}}{\text{CEPCI}_{2022}} = \frac{\$19}{\text{m}} \cdot 150\text{m} \cdot \frac{1324.2}{555.8} = \$6,790$$