HW 9

1a) 200 → 150 (Hot)

100 → 150 (Cool)

$q_1 = mC\Delta T = mc(T_i - T_0)$

$q_1 = 100000 \cdot 1.000 (200-150) = 500000 \frac{BTU}{hr}$

$q_1 = q_2$

$q_2 = mC(T_0 - T_i) \rightarrow T_0 = T_i + \frac{q_2}{mC} = 100 + \frac{500000}{100000 \cdot 1.000} = 150.05$

$q = UA\Delta T_{lm}$ $\quad 100 \begin{cases} 200 \rightarrow 150 \\ 100 \rightarrow 150.05 \end{cases} 0.05 \rightarrow \Delta T_{lm} = \frac{100 - 0.05}{\ln 100/0.05}$

$\Delta T_{lm} = 49.98\ ^\circ F$

$\therefore A = \frac{q}{U\Delta T_{lm}} = \frac{500000}{400 \cdot 49.98} = 250.4\ ft^2$

b) 200 → 150

150.05 ← 100

$q = mC\Delta T = 500000 \frac{BTU}{hr}$

$T_0 = T_i + \frac{q}{mC} = 150.05$

$\Delta T_{lm} = \frac{50.05 - 50}{\ln 50.05/50} \simeq 50^\circ f$

$A = \frac{q}{U\Delta T_{lm}} = \frac{500000}{100000 \cdot 50} = 250.2\ ft^2$

HW 9

2) $q = mC\Delta T \qquad q = UA\Delta T_{lm}$

$mC\Delta T = UA\Delta T_{lm} \rightarrow \Delta T_{lm} = \frac{mC\Delta T}{UA} = \frac{20000 \cdot 0.5 \cdot 80}{100 \cdot 300}$

$\Delta T_{lm} = 26.67 = \frac{(180-x)-(100-80)}{\ln\left(\frac{180-x}{20}\right)} \rightarrow$ **$x = 145.3\ ^\circ F$**

$180 \longrightarrow 100$

$x \longleftarrow 80$

---

3) $Re_{in} = \frac{D\rho v}{\mu} = \frac{0.025 \cdot 998.4}{0.000306} = 32587$

$T_{ci} \simeq 50^\circ C = \frac{90+20}{2}$

ρ
μ
k
Pr

$Re_{in} = \frac{D\rho v}{\mu} = \frac{0.025 \cdot 998.4}{.000498} = 200200.8 \rightarrow$ Turbulent

$Nu = 0.023 Re^{4/5} \cdot Pr^{0.4} = 0.023 \cdot 200200^{4/5} \cdot 3.15^{0.4}$

$Nu_w = 634 \rightarrow h_w = \frac{634 \cdot 0.65}{0.025} = 16489 \frac{W}{m^2 K}$

$Re_{oil} = \frac{(0.0375 - 0.025 - 0.0008) \cdot 865.8 \cdot 7}{0.0836} = 848 \rightarrow$ Laminar

$\therefore Nu \simeq 5.45 \rightarrow h_{oil} = \frac{0.141 \cdot 5.45}{(0.0375 - 0.025 - 0.0008)} = 65.68 \frac{W}{m^2 K}$

$U = \frac{1}{\frac{1}{h_w} + \frac{1}{h_o}}$ **$= 65.4 \frac{W}{m^2 K}$**

Josh Whitehead
ChEn 3453

Hw 9

5) a) Exit T for water: $T = 111.2\ ^\circ F$

b) Over Design Factor: 9.80%

6) a) Steam flow rate: $8687.6\ \frac{Lb}{hr}$

b) Over Design Factor: -1.80%

~~Pressure~~ ΔP_{tubes} not acceptable → Specified: 10
Calculated ≃ 53

ΔP_{shell} is acceptable

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Apps | CIS | Chemical Engineeri... | Nuclear Engineering | Chemistry | NSLS | Fastweb | Periodic Table - Pta... | Nuclides | Handshake | ProMax | Reading list

Project Viewer - ProMax@Drawing1

File ProMax Window

US English

- Flowsheets
  - Flowsheet1
    - Process Streams
      - Octane In
      - Octane Out
      - Water In
      - Water Out
    - Energy Streams
    - Blocks
      - XCHG-100
- Calculators
- User Value Sets
- Recoveries
- Energy Budgets
- Environments
- Mixed Species Collection
- Oils
- Reaction Sets
- Solver Summary
- Warnings

Name: XCHG-100 | Execute

Connections | Process Data | Rating | Streams | Tables | Plots | Notes

Streams
Properties
Composition

Stream		Water In	Octane In	Water Out	Octane Out	XCHG-100 - QA	XCHG-100 - QB
From Block				XCHG-100	XCHG-100	XCHG-100	XCHG-100
To Block		XCHG-100	XCHG-100			XCHG-100	XCHG-100
Temperature	°F	197	55	111.211	128		
Pressure	psia	110	435	100	300		
Mole Fraction Vapor	%	0	0	0	0		
Mole Fraction Light Liquid	%	100	100	100	100		
Mole Fraction Heavy Liquid	%	0	0	0	0		
Molecular Weight	lb/lbmol	18.0153	114.229	18.0153	114.229		
Mass Density	lb/ft^3	60.2166	44.5226	61.8061	42.3808		
Molar Flow	lbmol/h	11101.7	3939.47	11101.7	3939.47		
Mass Flow	lb/h	200000	450000	200000	450000		
Vapor Volumetric Flow	ft^3/h	3321.34	10107.2	3235.93	10618		
Liquid Volumetric Flow	gpm	414.09	1260.12	403.44	1323.81		
Std Vapor Volumetric Flow	MMSCFD	101.11	35.8792	101.11	35.8792		
Std Liquid Volumetric Flow	sgpm	399.814	1273.19	399.814	1273.19		
Compressibility		0.00466989	0.202065	0.00475774	0.128212		
Specific Gravity		0.965493	0.71386	0.990978	0.679519		
API Gravity		9.98669	67.3388	9.9879	67.6074		
Enthalpy	Btu/h	-1.34058e+09	-4.2818e+08	-1.35749e+09	-4.11269e+08	1.69106e+07	-1.69106e+07
Mass Enthalpy	Btu/lb	-6702.89	-951.511	-6787.44	-913.932		
Mass Cp	Btu/(lb*°F)	0.993003	0.49892	0.98093	0.543331		
Ideal Gas CpCv Ratio		1.32003	1.04797	1.32389	1.04289		

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Project Viewer - ProMax@Drawing1

File ProMax Window

US English

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Name: XCHG-100 | Execute

Connections | Process Data | Rating | Streams | Tables | Plots | Notes

Overall
- Results
- Shell
- Baffles
- Tubes
- Fins
- Internals
- Notes

XCHG-100 - A
- Side
- Pipes

XCHG-100 - B
- Side
- Pipes

Solve

Export...

Results

Fraction Over Design	9.79745	%
Area Available	3108.87	ft^2
Area Required	2831.46	ft^2
Overall U	96.4055	Btu/(h*ft^2*°F)
Clean U	96.4055	Btu/(h*ft^2*°F)
Bare U	96.4055	Btu/(h*ft^2*°F)
Service U	87.8031	Btu/(h*ft^2*°F)
Effective Overall UA	299712	Btu/(h*°F)
End Point UA	297617	Btu/(h*°F)
Duty	1.69106e+07	Btu/h
Corrected MTD	61.951	°F

Main Increment	Incremental Duty	Cumulative Fraction of Area	Metal Temperature	Delta Temperature	Metal Thermal Conductivity	Incremental U
	Btu/h	%	°F	°F	Btu/(h*ft*°F)	Btu/(h*ft^2*°F)
0	0	0	87.328	56.2107	8.65468	88.9913
1	1.69106e+06	11.6596	96.1704	57.2369	8.70199	91.6237
2	3.38213e+06	22.991	103.629	58.3262	8.7419	90.8203
3	5.07319e+06	34.0307	112.218	59.4761	8.78785	92.8819
4	6.76426e+06	44.6203	120.77	60.684	8.8336	94.8703
5	8.45532e+06	54.7846	129.286	61.9472	8.88695	96.7968
6	1.01464e+07	64.5467	137.764	63.2631	8.94138	98.6555

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Project Viewer - ProMax@Drawing1

File ProMax Window

US English

- Flowsheets
  - Flowsheet1
    - Process Streams
      - cold In
      - cold out
      - Condensate
      - steam in
    - Energy Streams
    - Blocks
      - XCHG-100
- Calculators
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Name: XCHG-100 | Execute

Connections | Process Data | Rating | Streams | Tables | Plots | Notes

Overall
- Results
- Shell
- Baffles
- Tubes
- Fins
- Internals
- Notes

XCHG-100 - A
- Side
- Pipes

XCHG-100 - B
- Side
- Pipes

Solve

Export...

Results

Fraction Over Design	-1.80844	%
Area Available	118.019	ft^2
Area Required	120.193	ft^2
Overall U	243.393	Btu/(h*ft^2*°F)
Clean U	398.58	Btu/(h*ft^2*°F)
Bare U	243.393	Btu/(h*ft^2*°F)
Service U	247.876	Btu/(h*ft^2*°F)
Effective Overall UA	28725.1	Btu/(h*°F)
End Point UA	28710.2	Btu/(h*°F)
Duty	7.856e+06	Btu/h
Corrected MTD	268.544	°F

Main Increment	Incremental Duty	Cumulative Fraction of Area	Metal Temperature	Delta Temperature	Metal Thermal Conductivity	Incremental U
	Btu/h	%	°F	°F	Btu/(h*ft*°F)	Btu/(h*ft^2*°F)
0	0	0	144.259	285	8.98307	237.64
1	785600	9.6973	146.503	281.838	8.99748	238.353
2	1.5712e+06	19.4753	148.785	278.666	9.01213	239.046
3	2.3568e+06	29.3371	151.104	275.485	9.02702	239.725
4	3.1424e+06	39.2857	153.459	272.295	9.04214	240.39
5	3.928e+06	49.3241	155.848	269.096	9.05748	241.042
6	4.7136e+06	59.4556	158.269	265.889	9.07302	241.682

ProMax:ProMax!Project!Flowsheets!Flowsheet1!Blocks!XCHG-100!QManager!HEXRating
Warning: Heat exchanger is under designed.
Warning: Calculated pressure drop (53.6958 psi) exceeds specified pressure drop (10 psi) for side XCHG-100 - A.

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VMware Horizon

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Project Viewer - ProMax@Drawing1

File ProMax Window

US English

- Flowsheets
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      - cold In
      - cold out
      - Condensate
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Name: XCHG-100 | Execute

Connections | Process Data | Rating | Streams | Tables | Plots | Notes

Streams | Properties | Composition

Stream		cold In	steam in	cold out	Condensate	XCHG-100 - QA	XCHG-100 - QB
From Block				XCHG-100	XCHG-100	XCHG-100	XCHG-100
To Block		XCHG-100	XCHG-100			XCHG-100	XCHG-100
Temperature	°F	45	338	85	330		
Pressure	psia	50	114.696	40	102.913		
Mole Fraction Vapor	%	0	100	0	0		
Mole Fraction Light Liquid	%	100	0	100	100		
Mole Fraction Heavy Liquid	%	0	0	0	0		
Molecular Weight	lb/lbmol	18.0153	18.0153	18.0153	18.0153		
Mass Density	lb/ft^3	62.4816	0.2524	62.1302	56.3195		
Molar Flow	lbmol/h	11101.7	482.233	11101.7	482.233		
Mass Flow	lb/h	200000	8687.57	200000	8687.57		
Vapor Volumetric Flow	ft^3/h	3200.94	34419.8	3219.05	154.255		
Liquid Volumetric Flow	gpm	399.079	4291.31	401.336	19.2318		
Std Vapor Volumetric Flow	MMSCFD	101.11	4.392	101.11	4.392		
Std Liquid Volumetric Flow	sgpm	399.814	17.3671	399.814	17.3671		
Compressibility		0.00266188	0.956341	0.00198427	0.00388456		
Specific Gravity		1.00181	0.622021	0.996175	0.903008		
API Gravity		9.99397		9.99519	9.98755		
Enthalpy	Btu/h	-1.37052e+09	-4.91963e+07	-1.36266e+09	-5.70523e+07	-7.856e+06	7.856e+06
Mass Enthalpy	Btu/lb	-6852.6	-5662.84	-6813.32	-6567.12		
Mass Cp	Btu/(lb*°F)	0.98488	0.482042	0.981233	1.0613		
Ideal Gas CpCv Ratio		1.32705	1.31391	1.32512	1.31426		

ProMax:ProMax!Project!Flowsheets!Flowsheet1!Blocks!XCHG-100!QManager!HEXRating
Warning: Heat exchanger is under designed.
Warning: Calculated pressure drop (53.6958 psi) exceeds specified pressure drop (10 psi) for side XCHG-100 - A.

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