TEST 3

First discussion session (in my office) no later than March 12. This discussion session should be over ALL difficulties noticed. Test due on March 25 (right after spring break, although I'd prefer you are done before spring break).

Consider the retrofit design of a crude unit.

Hot Streams													
	TCR	MCR	LCR	KERO	LGO	HGO	OVHD	HVGO	LVGO	SR1	SR2	SRQ	
Fcp [kW/C]	106.20	117.81	233.98	33.79	31.98	25.05	122.69	130.94	47.40	66.32	28.23	24.20	
Tin [C]	140.18	210.00	303.56	170.11	248.82	276.98	117.71	250.55	178.55	359.97	290.00	359.55	
Tout [C]	39.53	162.98	270.23	60.00	110.00	121.91	50.00	90.00	108.87	290.00	115.00	280.00	
					Cold S	treams							
	C1	C2	С3	C4	C5	C6	C7	C8	С9	C10	C11	C12	
Fcp [kW/C]	200.04	223.73	228.00	230.91	236.67	246.35	255.25	265.83	328.06	371.49	373.8	413.6	
Tin [C]	30.00	130.00	145.00	153.74	161.90	185.00	216.66	234.84	270	290	310	330	
Tout [C]	130.00	145.00	153.74	161.90	185.00	216.66	234.84	270.00	290	310	330	350	

The system has two cold streams. The second cold stream is represented by piece wise sections (C2-C12) because the FCP varies with temperature (the stream vaporizes). The existing network is shown next.

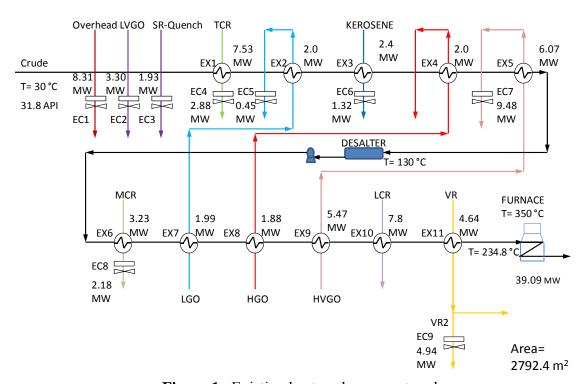


Figure 1. Existing heat exchanger network

Economic Data

Furnace Utility Costs (\$/Kw-yr)	\$100.00	Maximum area per shell (m²)	500
Area addition costs (\$/m²)	\$271.20	Installation cost as % of equipment cost	50%
Fixed exchanger cost (\$)	\$17,129	Furnace Efficiency	80%

Table 1. Heat exchanger flow rates and temperatures for example network

ran									·· r ·			
Exchanger	nanger EX		E)	< 2	E)	(3	E	(4	EX5			
Cold Stream	Crude BD		CRUDE BD		CRUE	CRUDE BD		CRUDE BD		CRUDE BD		
Flow (tonm/day)	8330.3		8330.3		8330.3		8330.3		8330.3			
	In	Out	In	Out	In	Out	In	Out	In	Out		
Temperature (°C)	30.0	70.0	70.0	80.0	80.0	91.9	91.9	101. 6	101. 6	130. 0	Desalter	
Hot Stream	TCR		LGO		KEROSENE		HGO		HV	GO	Crude T=130°C	
Flow (tonm/day)	4000.0		1100.0		1273.6		850.0		4760.6			
	In	Out	In	Out	In	Out	In	Out	In	Out		
Temperature	140.		190.	125.	170.	101.	206.	121.	212.	167.		
(°C)	2	69.3	0	4	1	5	0	9	6	6		
DUTY (MW)	7.	53	2.00		2.40		2.00		6.07			
Exchanger	EΣ	(6	E	< 7	E)	⟨8	E	(9	EX	10	EX	11
Exchanger Cold Stream		K6 DE AD		K7 DE AD		(8 DE AD	CRUE			10 DE AD		11 DE AD
	CRUE		CRUE		CRUE			E AD	CRUE		CRUE	
Cold Stream	CRUE	DE AD	CRUE	DE AD	CRUE	E AD	CRUE	E AD	CRUE	DE AD	CRUE	DE AD
Cold Stream Flow (tonm/day) Temperature	835 In 130.	OE AD 50.2 Out 145.	CRUE 835 In 145.	OE AD 60.2 Out 153.	835 In 153.	OE AD 00.2 Out 161.	835 In 161.	OE AD 0.2 Out 185.	CRUE 835 In 185.	OE AD 60.2 Out 216.	835 In 216.	OE AD 60.2 Out 234.
Cold Stream Flow (tonm/day)	CRUE 835 In	OE AD 60.2 Out	CRUE 835 In	OE AD 60.2 Out	CRUE 835 In	OE AD 60.2 Out	CRUE 835 In	OE AD O.2 Out	CRUE 835 In	OE AD 50.2 Out	CRUE 835 In	DE AD 50.2 Out
Cold Stream Flow (tonm/day) Temperature	835 In 130. 0	OE AD 50.2 Out 145.	835 In 145.	OE AD 60.2 Out 153.	835 In 153.	OE AD 00.2 Out 161.	835 In 161. 9	OE AD 0.2 Out 185.	835 In 185.	OE AD 60.2 Out 216.	835 In 216.	OE AD 60.2 Out 234.
Cold Stream Flow (tonm/day) Temperature (°C)	835 In 130. 0	OE AD 60.2 Out 145.	CRUE 835 In 145. 0	OE AD 60.2 Out 153. 7	835 In 153. 7	OE AD 60.2 Out 161. 9	835 In 161. 9	DE AD 0.2 Out 185. 0	CRUE 835 In 185. 0	OE AD 60.2 Out 216.	216. 7	OE AD 50.2 Out 234. 8
Cold Stream Flow (tonm/day) Temperature (°C) Hot Stream	835 In 130. 0	OE AD 50.2 Out 145. 0	CRUE 835 In 145. 0	OE AD 60.2 Out 153. 7	835 In 153. 7	OE AD 60.2 Out 161. 9	835 In 161. 9	DE AD 0.2 Out 185. 0	CRUE 835 In 185. 0	OE AD 50.2 Out 216. 7	216. 7	OE AD 60.2 Out 234. 8
Cold Stream Flow (tonm/day) Temperature (°C) Hot Stream Flow (tonm/day) Temperature	CRUE 835 In 130. 0 Mr 400 In 210.	OE AD 60.2 Out 145. 0 CR 00.0 Out 181.	CRUE 835 In 145. 0 LG 110 In 248.	OE AD 60.2 Out 153. 7 60 Out Out 190.	CRUE 835 In 153. 7 HC 85 In 277.	OE AD Out 161. 9 60 Out Out 206.	CRUE 835 In 161. 9 HV 476 In 250.	OE AD OO.2 Out 185. 0 GO OO.6 Out 212.	CRUE 835 In 185. 0 LG 70 In 303.	OE AD 60.2 Out 216. 7 CR 00 Out 270.	CRUE 835 In 216. 7 V 202 In 360.	OE AD 60.2 Out 234. 8 'R 23.5 Out 290.
Cold Stream Flow (tonm/day) Temperature (°C) Hot Stream Flow (tonm/day)	CRUE 835 In 130. 0 Mi 400	OE AD 60.2 Out 145. 0 CR 00.0 Out	CRUE 835 In 145. 0 LG 110	OE AD 60.2 Out 153. 7 60 00.0 Out	CRUE 835 In 153. 7 HG 85	OE AD 60.2 Out 161. 9 60 60 Out	CRUE 835 In 161. 9 HV 476	OE AD OO.2 Out 185. O GO OO.6 Out	CRUE 835 In 185. 0 LG 70	OE AD 60.2 Out 216. 7 CR Out Out	CRUE 835 In 216. 7 V 202 In	OE AD 60.2 Out 234. 8 R 23.5 Out

Table 2. Heater and cooler flow rates and temperatures for example network

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Heater/Cooler	Cooler EC1		EC2		EC3		EC4		EC5		EC6		
Stream	Overhead		LVGO		SR-Quench		TCR		LGO		KEROSENE		
Flow (tonm/day)	994.3		1653.7		662.4		4000.0		1100.0		1273.6		
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	
Temperature (°C)	117.7	50.0	178.6	108.9	359.6	280.0	140.2	69.3	125.4	110.0	101.5	60.0	
DUTY (MW)	8.31		3.30		1.93		2.88		0.45		1.32		
Heater/Cooler	EC	7	E	C8	E	C9	FURN	NACE					

Stream	HVGO		MCR		VR2		CRUDE AD	
Flow (tonm/day)	476	0.6	400	0.0	202	.3.5	835	0.2
	In	Out	In	Out	In	Out	In	Out
Temperature (°C)	167.6	90.0	181.9	163.0	290.0	115.0	234.8	350.0
DUTY (MW)	9.48 2.18		4.94		39.09			

Table 3. Overall heat transfer coefficients and areas for example network

	EX1	EX2	EX3	EX4	EX5	EX6	EX7	EX8	EX9	EX10	EX11
$U (MW/m^2-K)$	0.2	0.4	0.3	0.35	0.2	0.2	0.4	0.35	0.2	0.28	0.31
Area (m ²)	707	63	182	96	411	240	74	68	473	324	154

PROVIDE A RETROFIT DESIGN USING PINCH TECHNOLOGY YOUR LOWEST POSSIBLE EMAT is 5 °C): Your goal is to beat the following answer obtained using a linear model (HIT; discussed briefly in class): Hot utility: 25.96 MW, Area 6627 m², (new area=3882 m²), 13 new shells, Investment: 4,060,000, Savings \$1,641,250 \$/yr, NPV=\$6,024,000, IRR=39%. Use the following steps:

- 1) **Perform Pinch Retrofit Targeting:** Use different values of α . As an economic objective, use NPV (10 years and a rate of 10%).
- 2) Identify matches that cross the pinch.
- 3) Perform Pinch Design for the HRAT recommended in 1): Carefully make your choices so that existing matches coincide with your matches. Use the transshipment model when appropriate to obtain alternatives. We will discuss an exclusion constraint in class.
- 4) Obtain a first retrofit design by placing new exchangers as suggested by the design obtained in 3). Can driving forces plot help here?
- 5) Identify loops that can allow you to transfer area from exchangers with area larger than the existing one to new exchangers. You can use this technique when designing step 3) and/or after the first answer in step 4 was obtained. Which is best? Use paths only if needed.
- 6) Can you use criss-crossing to obtain a better network? You can use this technique when designing step 3) and/or after the first answer in step 4 was obtained. Which is best?
- 7) Consider now that the furnace is working NOW at its given efficiency. Read the attached article and figure out how much the efficiency of a box-type furnace will change.