EN 410
Energy Management

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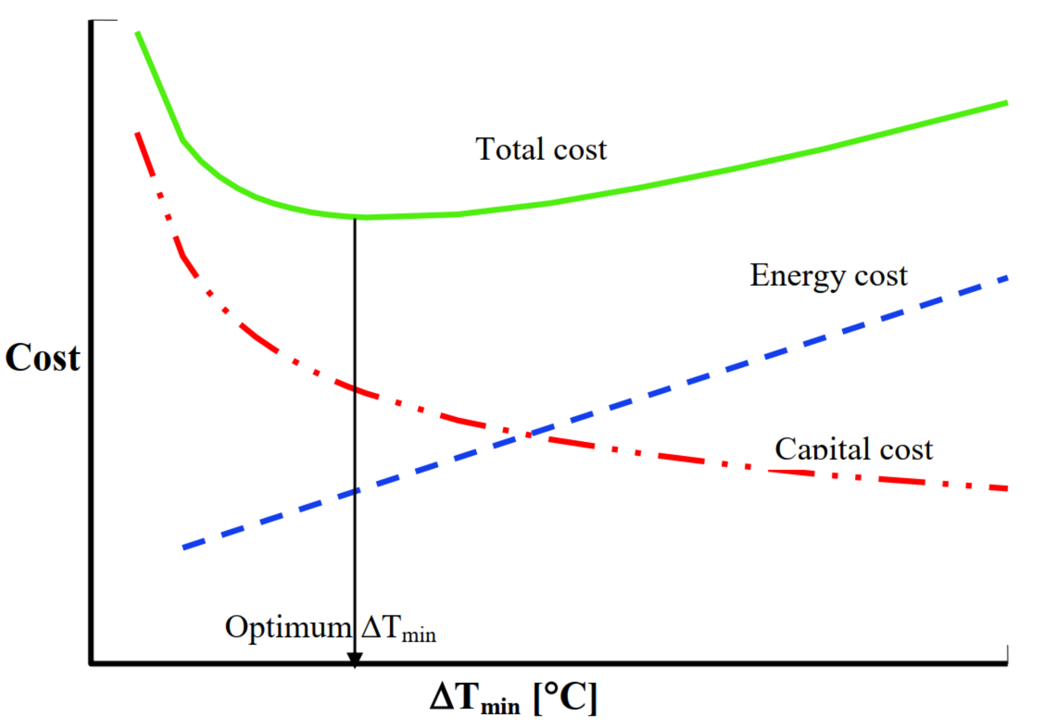
Minimum temperature difference

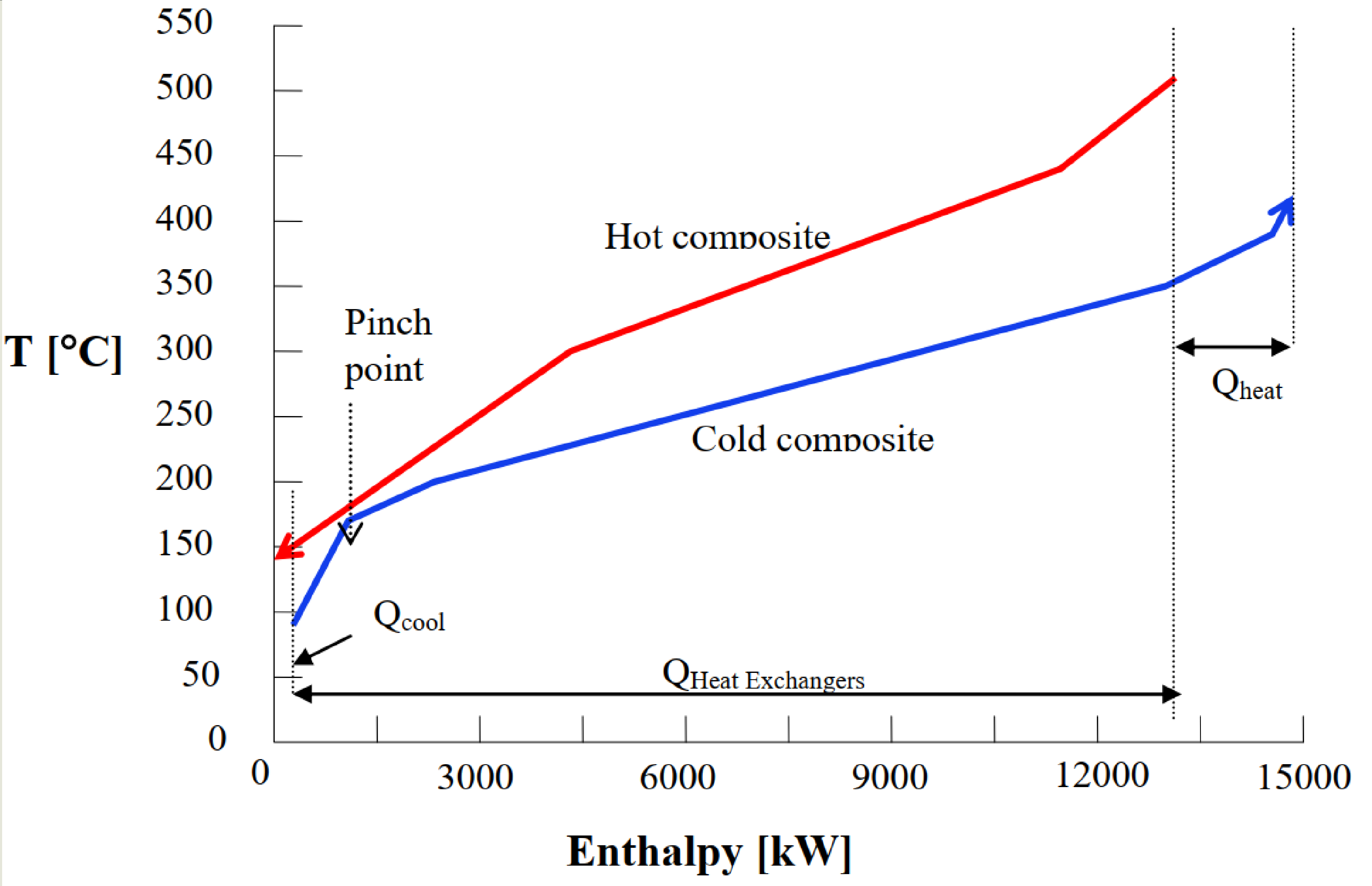
$$Q = AU\,\Delta T_{lm}$$

- Higher the ΔT lesser the area, lesser the heat recovery, larger the external utilities
- Vice versa



Industrial Sector	Typical values for ΔT_{min}
Low Temperature Process	3 – 5 °C
Chemical	10 – 20 °C
Petrochemical	10 – 20 °C
Oil Refinery	20 – 40 °C

Composite curve for hot and cold streams



No heat transfer across pinch, otherwise the system needs more external utilities than the thermodynamic minimum

Problem table approach

- ΔT_{min} = 10°C
- Divide among the streams or
- Increase the cold stream temperature or
- Decrease the hot stream temperature

1. Estimate the new temp of streams

	Process stream type	Inlet temp	Outlet temp	Heat capacity rate	Q
	-	°C	°C	kW/K	kW
1	Cold	90	420	10	3300
2	Cold	170	350	32	5760
3	Cold	200	390	29	5510
4	Hot	440	140	27	8100
5	Hot	510	300	24	5040

	Process stream type	Inlet temp	Outlet temp	Heat capacity rate
	-	°C	°C	kW/K
1	Cold	90	420	10
2	Cold	170	350	32
3	Cold	200	390	29
4	Hot	430	130	27
5	Hot	500	290	24

Problem table approach

2. Estimate the new temp intervals and Q

Interval Number	Temperature interval [°C]	Stream Numbers
1	500 – 430	5
2	430 – 420	4 + 5
3	420 – 390	1 + 4 + 5
4	390 – 350	1 + 3 + 4 + 5
5	350 – 290	1 + 2 + 3 + 4 +5
6	290 – 200	1 + 2 + 3 + 4
7	200 – 170	1 + 2 + 4
8	170 – 130	1 + 4
9	130 – 90	1

Estimate the energy availability

3. Estimate the excess energy in each interval

$$D_i = (T_i - T_{i+1})\left[\sum\left(\dot{m}C_p\right)_{cold} - \sum\left(\dot{m}C_p\right)_{hot}\right]$$

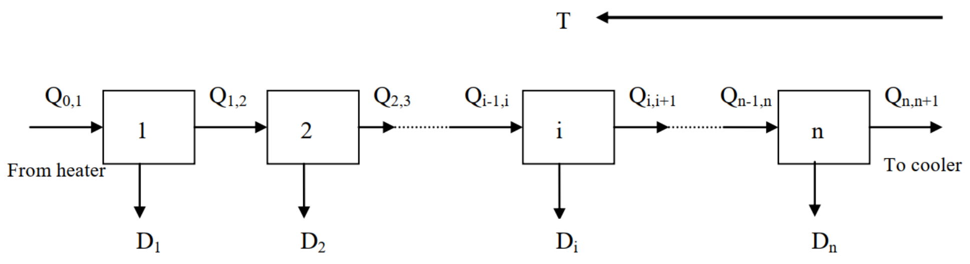
$D_i < 0 \Rightarrow$ need for cooling
$D_i > 0 \Rightarrow$ need for heating

Interval Number	Temperature interval [°C]	Stream Numbers	D_i
1	500 – 430	5	-1680
2	430 – 420	4 + 5	-510
3	420 – 390	1 + 4 + 5	-1230
4	390 – 350	1 + 3 + 4 + 5	-480
5	350 – 290	1 + 2 + 3 + 4 +5	1200
6	290 – 200	1 + 2 + 3 + 4	3960
7	200 – 170	1 + 2 + 4	450
8	170 – 130	1 + 4	-680
9	130 – 90	1	400

	Process stream type	Heat capacity rate
	-	kW/K
1	Cold	10
2	Cold	32
3	Cold	29
4	Hot	27
5	Hot	24

Estimate the sequential balance

4. Estimate the supplied heat to the each interval



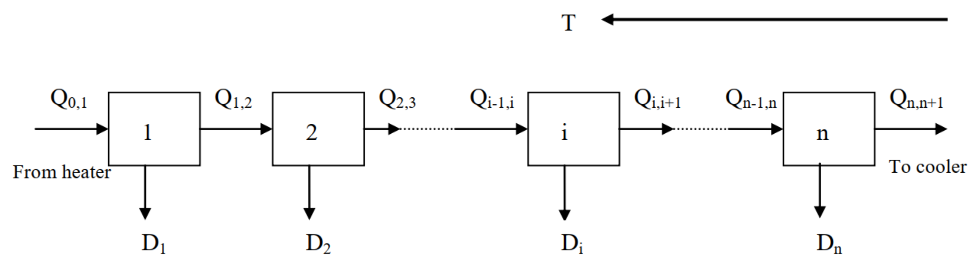
$$\dot{Q}_{i,i+1} = \dot{Q}_{i-1,1} - D_i$$

Interval	Temp. limits	D_i	Sequential Balance $\dot{Q}_{i-1,i}$	$\dot{Q}_{i,i+1}$
1	500 – 430	-1680	0	1680
2	430 – 420	-510	1680	2190
3	420 – 390	-1230	2190	3420
4	390 – 350	-480	3420	3900
5	350 – 290	1200	3900	2700
6	290 – 200	3960	2700	-1260
7	200 – 170	450	-1260	*-1710*
8	170 – 130	-680	-1710	-1030
9	130 – 90	400	-1030	-1430

Minimum utility load which must be added to the network to avoid any deficit at lower intervals

Problem table approach

5. Estimate the new supplied heat to the each interval, 1710 kW as load input in the interval 1



$$\dot{Q}_{i,i+1} = \dot{Q}_{i-1,1} - D_i$$

Interval	Temp. limits	D_i	Sequential Balance $\dot{Q}_{i-1,i}$	Sequential Balance $\dot{Q}_{i,i+1}$	Max Table $\dot{Q}_{i-1,i}$	Max Table $\dot{Q}_{i,i+1}$
1	500 – 430	-1680	0	1680	***1710***	3390
2	430 – 420	-510	1680	2190	3390	3900
3	420 – 390	-1230	2190	3420	3900	5130
4	390 – 350	-480	3420	3900	5130	5610
5	350 – 290	1200	3900	2700	5610	4410
6	290 – 200	3960	2700	-1260	4410	450
7	200 – 170	450	-1260	*-1710*	450	***0***
8	170 – 130	-680	-1710	-1030	***0***	680
9	130 – 90	400	-1030	-1430	680	***280***

- Pinch temperature = 170°C (for cold= = 170°C , hot = 180°C)
- Minimum heating utility = 1710 kW
- Minimum cooling utility = 280 kW

Composite curve for hot and cold streams