458.401 Process & Product Design

14

Pinch Technology (2)

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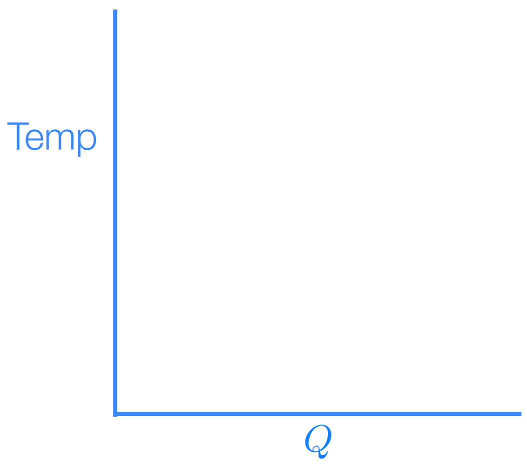
Graphical Method

- It is possible to generate the same Maximum Energy Recovery solution using a <u>second</u> method.
  - We can use this method for verification of the first method.
- The key results remain as
  - Where is the pinch?
  - What is the cold utility demand?
  - What is the hot utility demand?

Graphical Method

$$Q = (mC_p) \cdot \Delta T$$

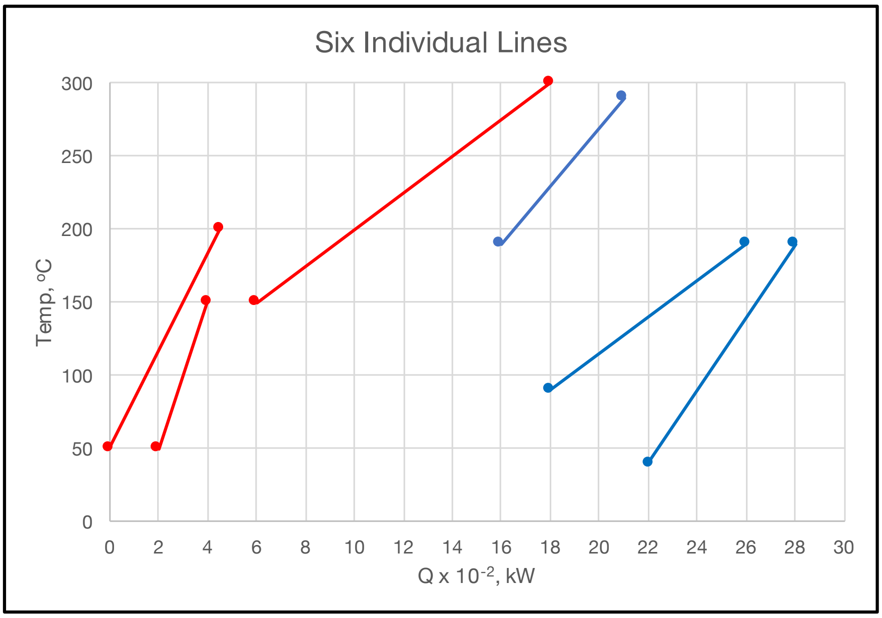


$$\square = \left(\frac{1}{mC_p}\right) \cdot \square$$

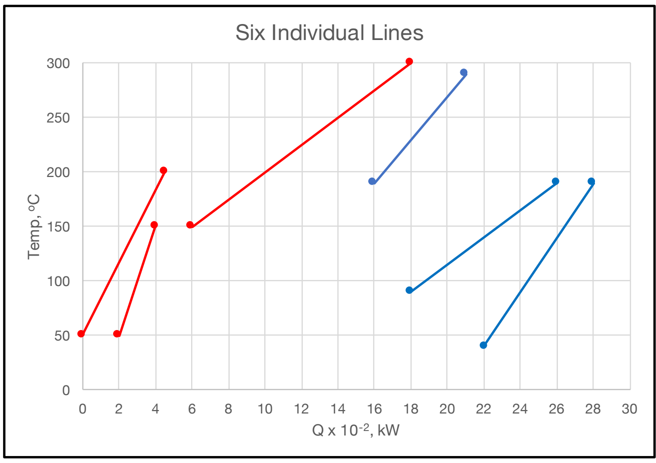
$$y = m \cdot x$$

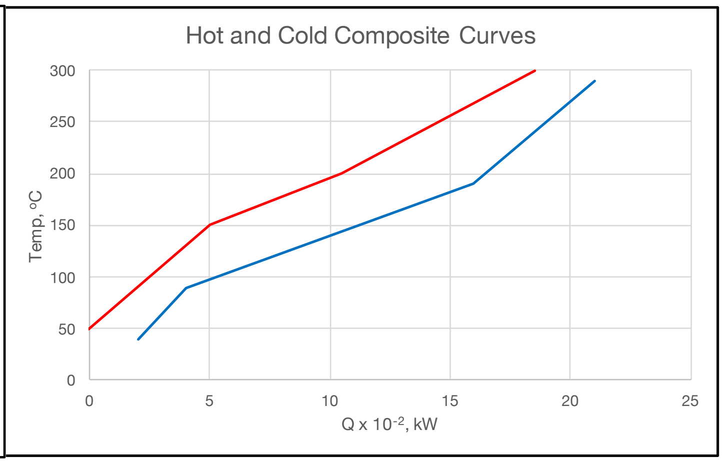
$$\text{Slope} = \frac{\Delta y}{\Delta x}$$

Graphical Method

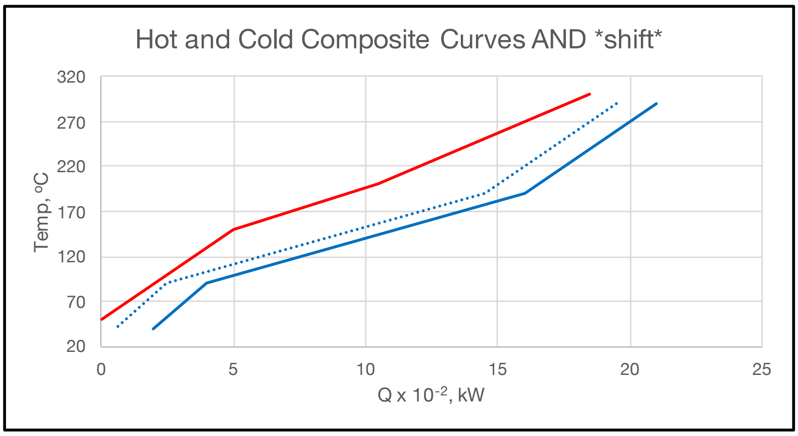


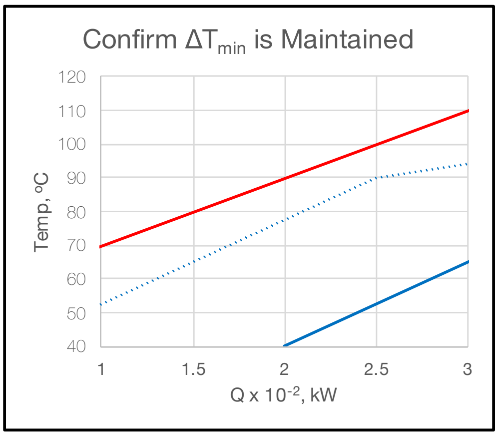
Graphical Method





Graphical Method



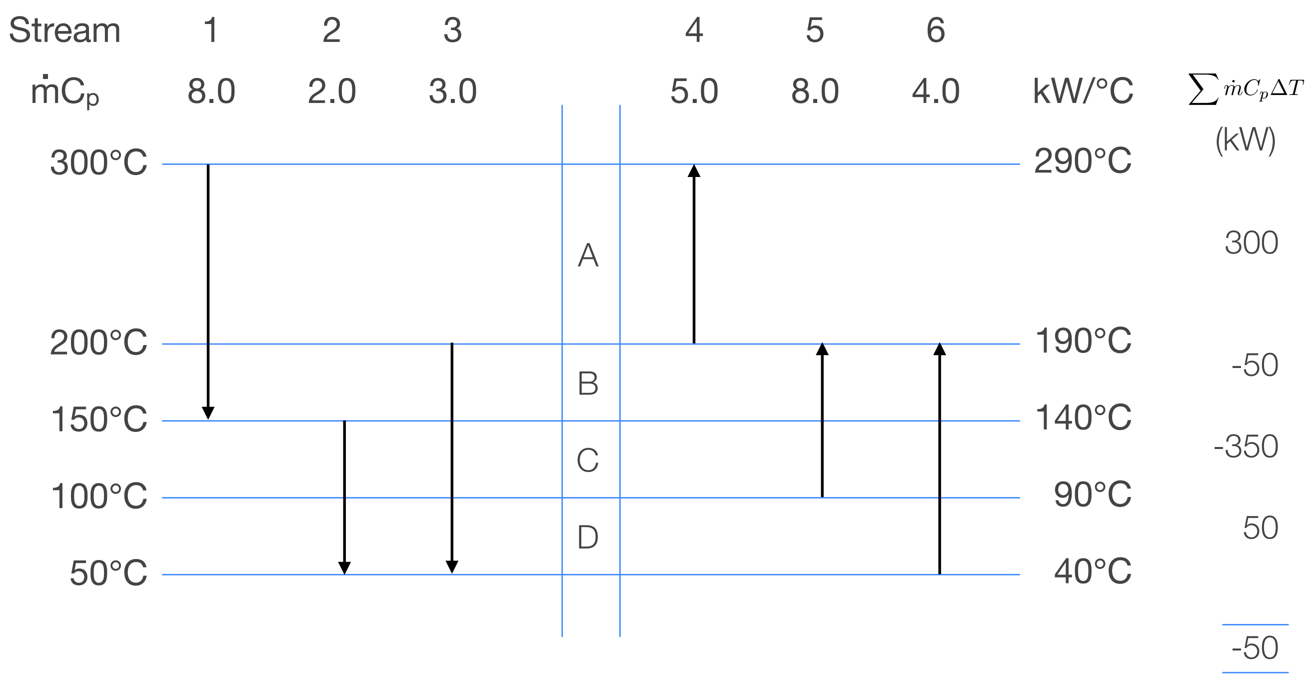


Pinch location = _____°C (hot streams) and _____°C (cold streams)

Total cooling water demand = _____ kW

Total steam demand = _____ kW

Temperature Interval Diagram



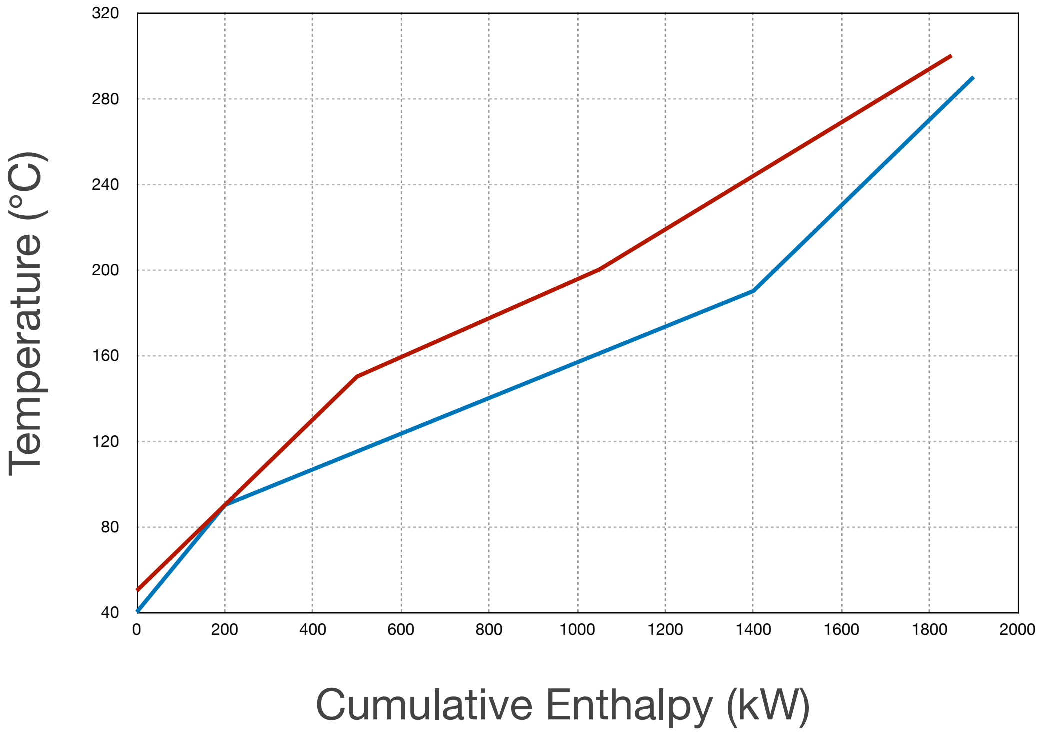
Hot Streams

Temperature Interval	Temperature (°C)	Enthalpy of Hot Streams in Temperature Interval (kW)	Cumulative Enthalpy of Hot Streams (kW)
	50	0	0
D	100	(2 + 3)(100 - 50) = 250	250
C	150	(2 + 3)(150 - 100) = 250	500
B	200	(8 + 3)(200 - 150) = 550	1050
A	300	(8)(300 - 200) = 800	1850

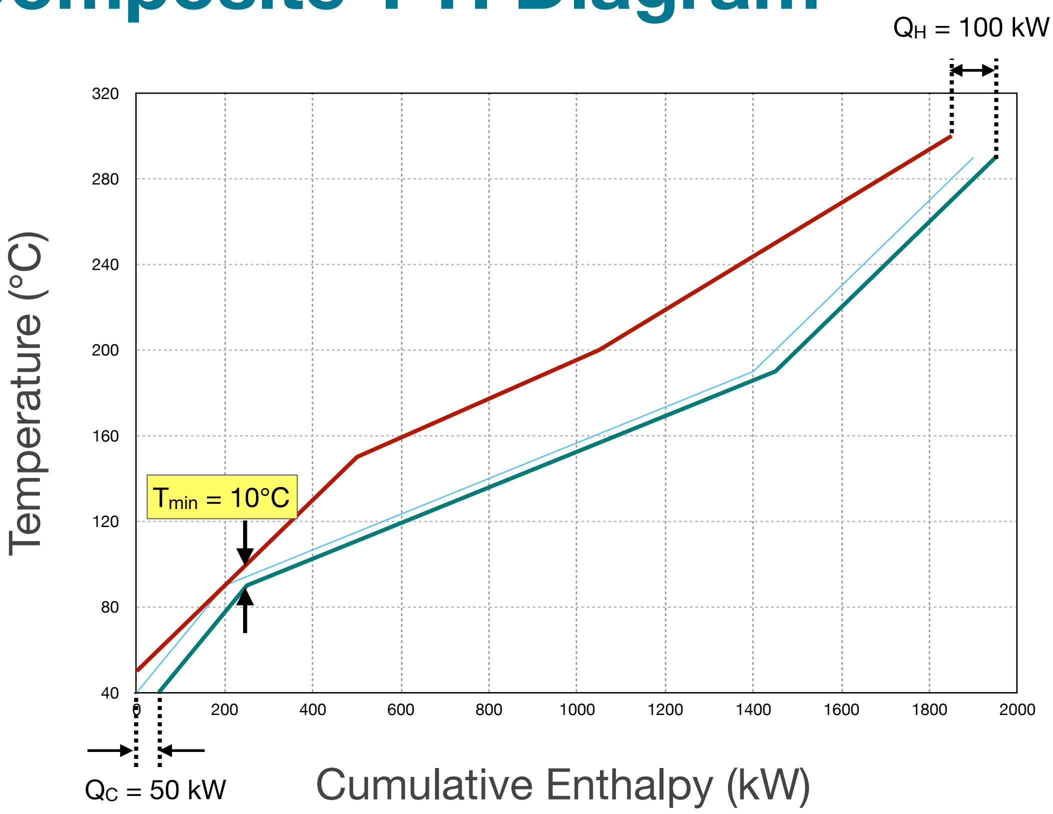
Cold Streams

Temperature Interval	Temperature (°C)	Enthalpy of Cold Streams in Temperature Interval (kW)	Cumulative Enthalpy of Cold Streams (kW)
	40	0	0
D	90	(4)(90 - 40) = 200	200
C	140	(8 + 4)(140 - 90) = 600	800
B	190	(8 + 4)(190 - 140) = 600	1400
A	290	(5)(290 - 190) = 500	1900

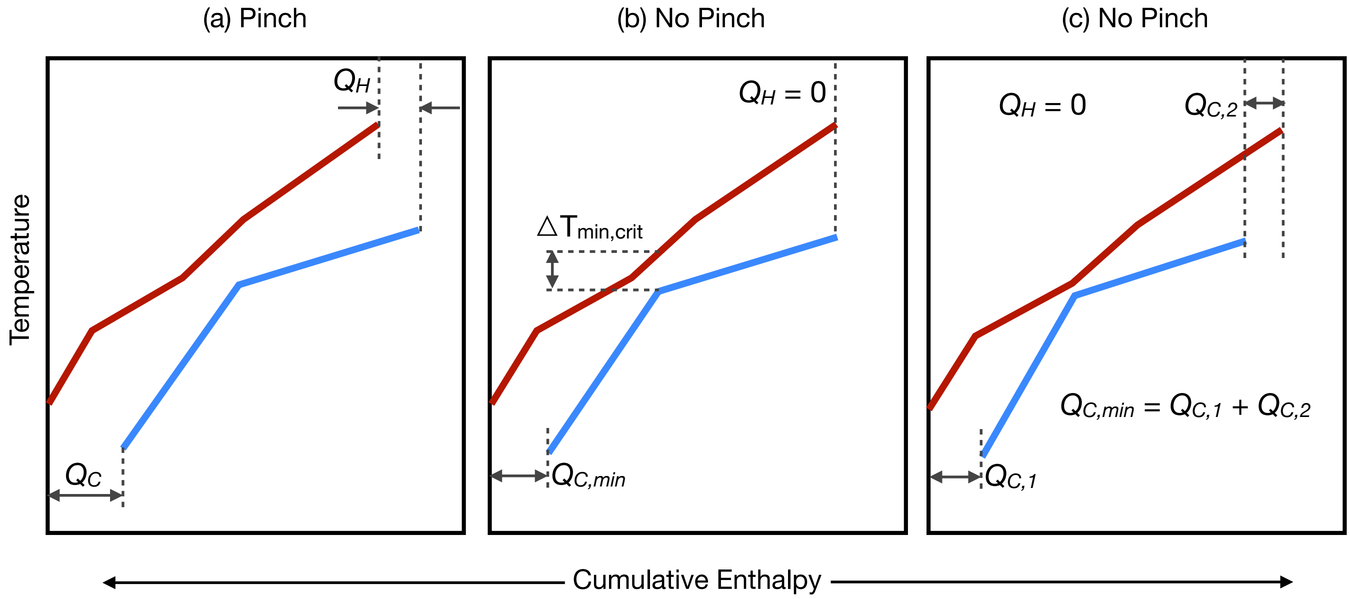
Composite T-H Diagram



Composite T-H Diagram



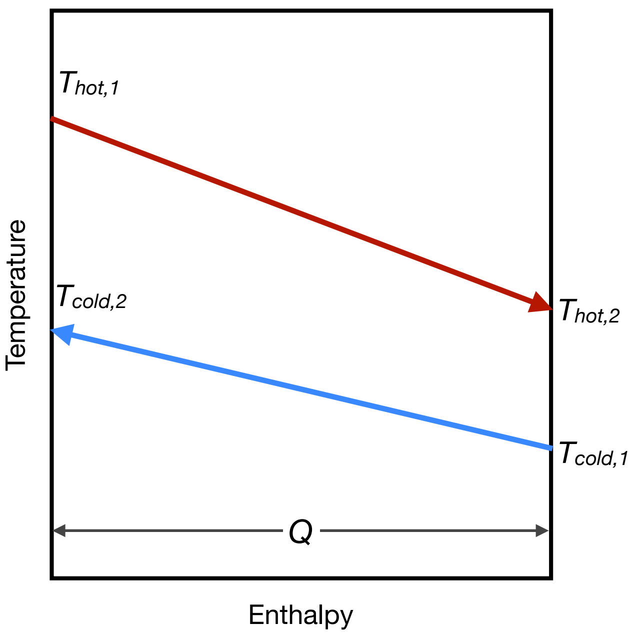
Systems Without a Pinch

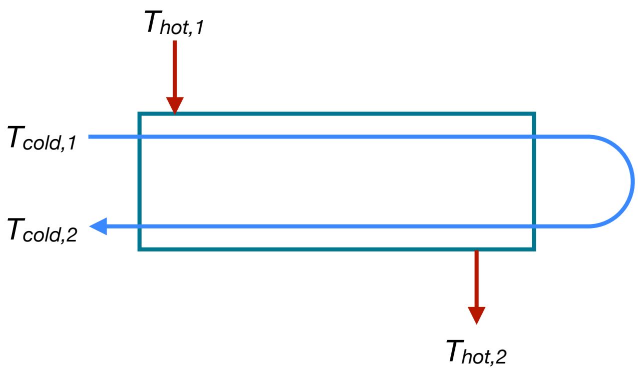


At $\Delta T_{min,crit}$, the hot utility requirement (Q_H) becomes zero and the cold utility requirement becomes a minimum

If $\Delta T_{min} < \Delta T_{min,crit}$, heat must be rejected to the cold utility at the high temperature end as well as the low temperature end. However, $Q_{c,min}$ remains constant. Hence, below $T_{min,\ crit}$, the cold utility duty is constant and the hot utility duty is zero.

Estimation of Heat-Exchanger Area



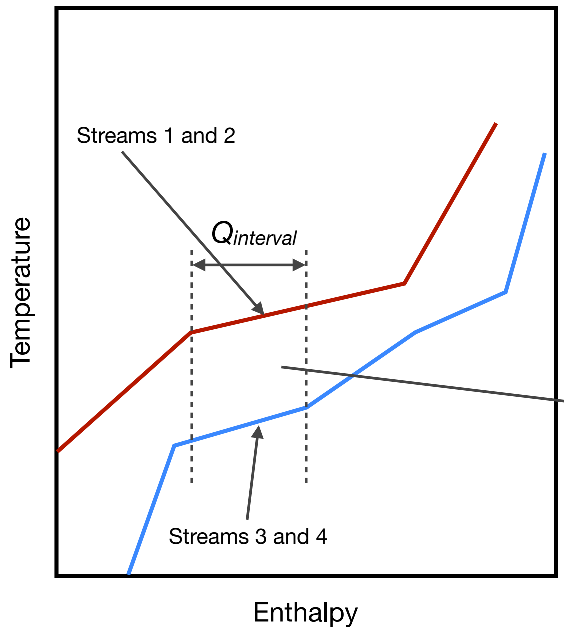


$$Q = UA\Delta T_{lm}F$$

↓

$$A = \frac{Q}{F\Delta T_{lm}}\left(\frac{1}{h_{hot}} + \frac{1}{h_{cold}}\right)$$

Estimation of Heat-Exchanger Area



$$Q_{interval} = Q_1 + Q_2 = Q_3 + Q_4$$

$$A_{\text{interval}} = \frac{1}{F\Delta T_{lm,\text{interval}}}\left(\sum_{i=1}^{\text{hot streams}} \frac{Q_i}{h_i} + \sum_{i=1}^{\text{cold streams}} \frac{Q_i}{h_i}\right)$$

Example 15.5