CHE526: PINCH TECHNOLOGY

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The Tabular Method

1. Represent the streams as vertical lines drawn between their initial and final temperatures.
2. Adjust the temperatures by adding ½ the minimum allowable temperature difference to the cold stream temperatures and subtracting same from the hot stream temperatures.
3. The streams are then re-drawn as vertical lines between the adjusted temperatures
4. Interval temperatures and enthalpy are calculated using the expression

$$([\sum CPC - \sum CPH] * \Delta t)$$

   a) a decrease in enthalpy (-ve sign) represents a surplus of energy available for heat transfer
   b) an increase in enthalpy (+ve sign) represents a deficit of energy requiring a transfer of heat
5. The total deficit and surplus are determined. Starting with the first interval, the total deficit is supplied as external heating and added cumulatively to the intervals all through to the last interval that yield the value for the external cooling required, same as the surplus calculated.
6. The interval temperature at which there is a zero deficit corresponds to the pinch point.
7. The actual hot and cold stream pinch point are then determined by adding ½ the minimum allowable temperature difference to the pinch point for hot stream and subtracting same from the pinch point for the cold stream.
8. A plot of the adjusted temperatures and the interval enthalpies gives the Grand Composite Curve (GCC)

Stream Data

Hot Stream	F_iCp_i ($kW/^oC$)	Supply (^oC) T_2^i	Target (^oC) T_1^i	Enthalpy Change HH_i, (kW)
H_1	400	340	260	32000
H_2	350	400	360	14000
H_3	300	450	380	21000

Cold Stream	F_iCp_i ($kW/^oC$)	Supply (^oC) t_1^i	Target (^oC) t_2^i	Enthalpy Change HC_i, (kW)
C_1	250	240	290	12500
C_2	300	300	400	30000
C_3	450	350	400	22500

Algebraic Method

- This same problem will now be solved using the algebraic method
- This will involve producing a temperature interval diagram, tables of exchangeable heat loads, and cascade diagrams

Stream Data

From before:

Hot Stream	F_iCp_i (kW/°C)	Supply (°C) T_2^i	Target (°C) T_1^i
H_1	400	340	260
H_2	350	400	360
H_3	300	450	380

Cold Stream	F_iCp_i (kW/°C)	Supply (°C) t_1^i	Target (°C) t_2^i
C_1	250	240	290
C_2	300	300	400
C_3	450	350	400

Temperature Interval Diagram

- The first step is to construct the temperature interval diagram
- This diagram shows the starting and finishing temperatures of each stream
- An interval begins at a stream's starting or finishing temperature, and it ends where it encounters the next beginning or finishing temperature of a stream
  - Draw horizontal lines across the table at each arrow's head and tail, with the intervals lying between these lines
- Note how the cold stream temperature scale is staggered by 10 degrees

Temperature Interval Diagram

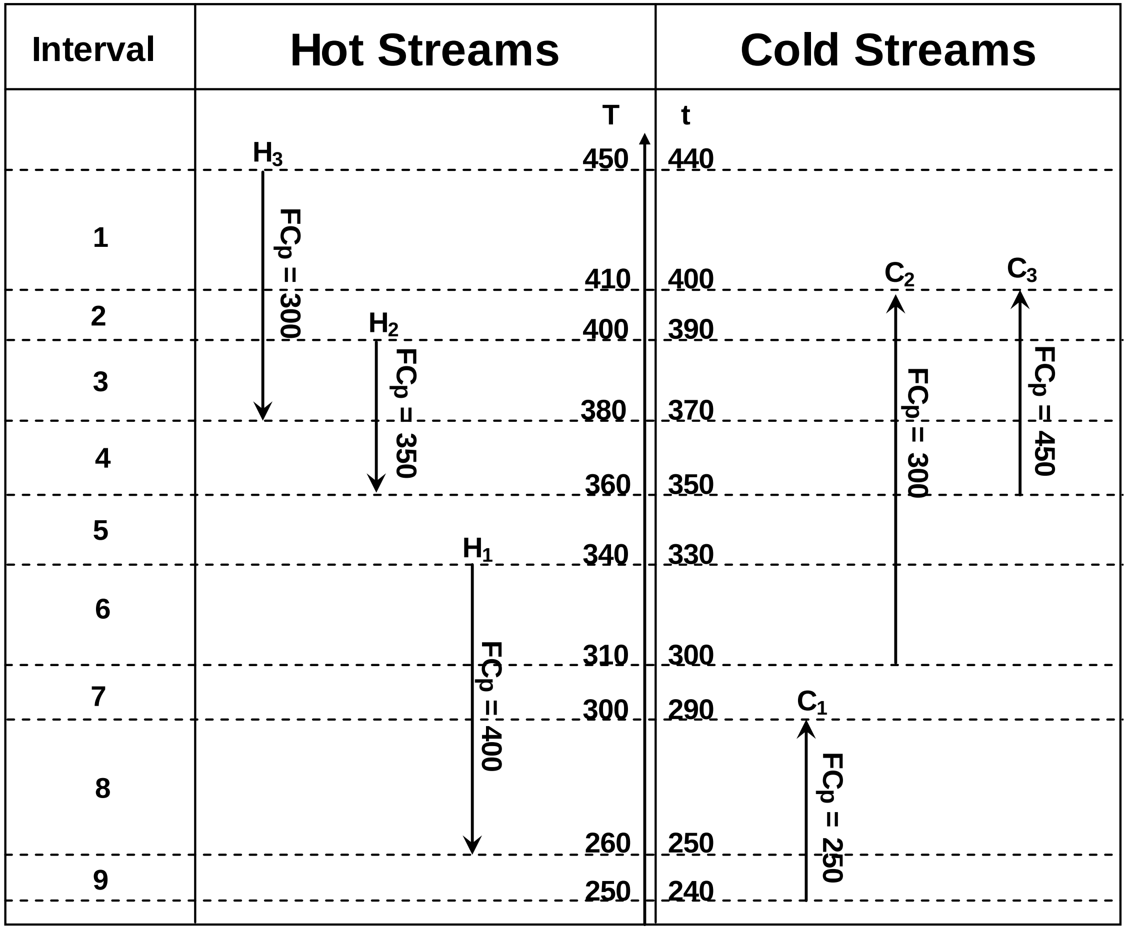


Table of Exchangeable Heat Loads

- The next step is to construct tables of exchangeable heat loads for the hot and cold streams
- These tables show the amount of energy that must be added or removed from a stream over a particular interval
- These energy values are calculated as

$\Delta H_{j,i} = FC_{pj}\Delta T_i$, where ΔT_i is the positive temperature difference across the interval, and j denotes the stream number

Table of Exchangeable Heat Loads

- For the hot streams,

Table of Exchangeable Loads - Hot Streams

Interval i	$H_{1,i}$ kW	$H_{2,i}$ kW	$H_{3,i}$ kW	Total, HH_i kW
1	-	-	12000	12000
2	-	-	3000	3000
3	-	7000	6000	13000
4	-	7000	-	7000
5	-	-	-	0
6	12000	-	-	12000
7	4000	-	-	4000
8	16000	-	-	16000
9	-	-	-	0
Total cooling required (kW)				67000

Table of Exchangeable Heat Loads

- For the cold streams,

Table of Exchangeable Loads - Cold Streams

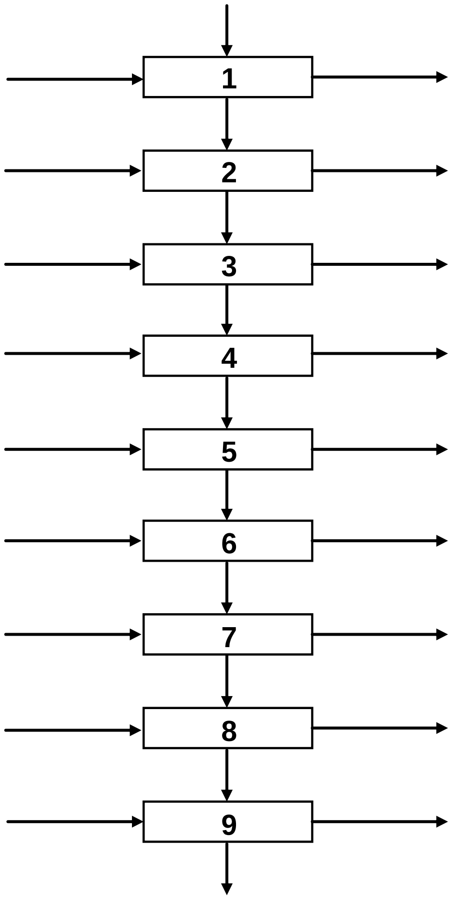
Interval i	$C_{1,i}$ kW	$C_{2,i}$ kW	$C_{3,i}$ kW	Total, HC_i kW
1	-	-	-	0
2	-	3000	4500	7500
3	-	6000	9000	15000
4	-	6000	9000	15000
5	-	6000	-	6000
6	-	9000	-	9000
7	-	-	-	0
8	10000	-	-	10000
9	2500	-	-	2500
Total heating required (kW)				65000

Cascade Diagrams

- Using the information from the heat load tables, the cascade diagrams can now be constructed
- These diagrams will be used to determine the pinch point and the minimum heating and cooling utilities required

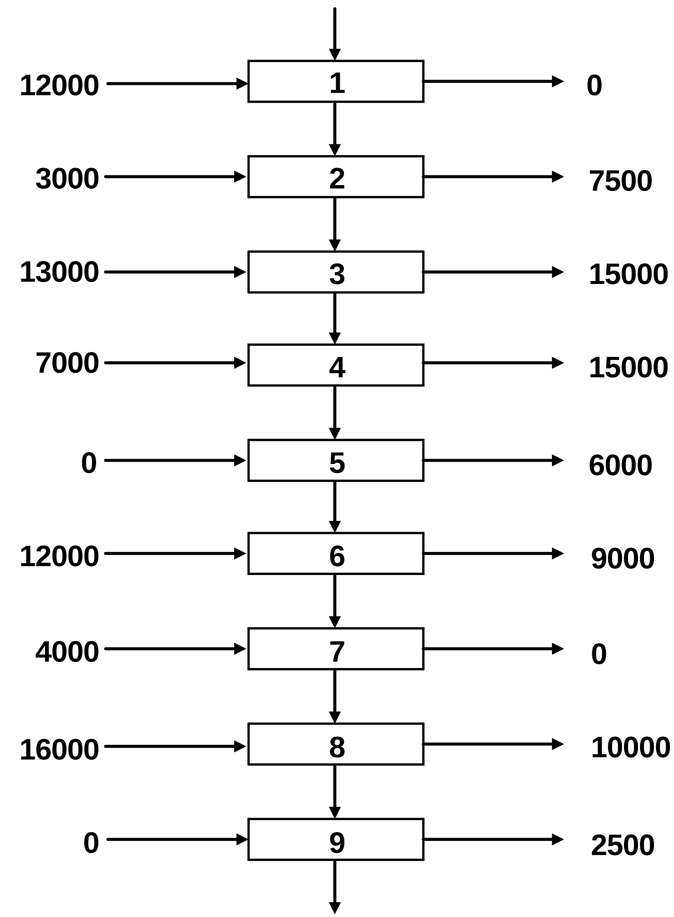
Cascade Diagram

- First, the cascade diagram is drawn as it appears at right, with one box for each interval that appeared in the temperature interval diagram



Cascade Diagram

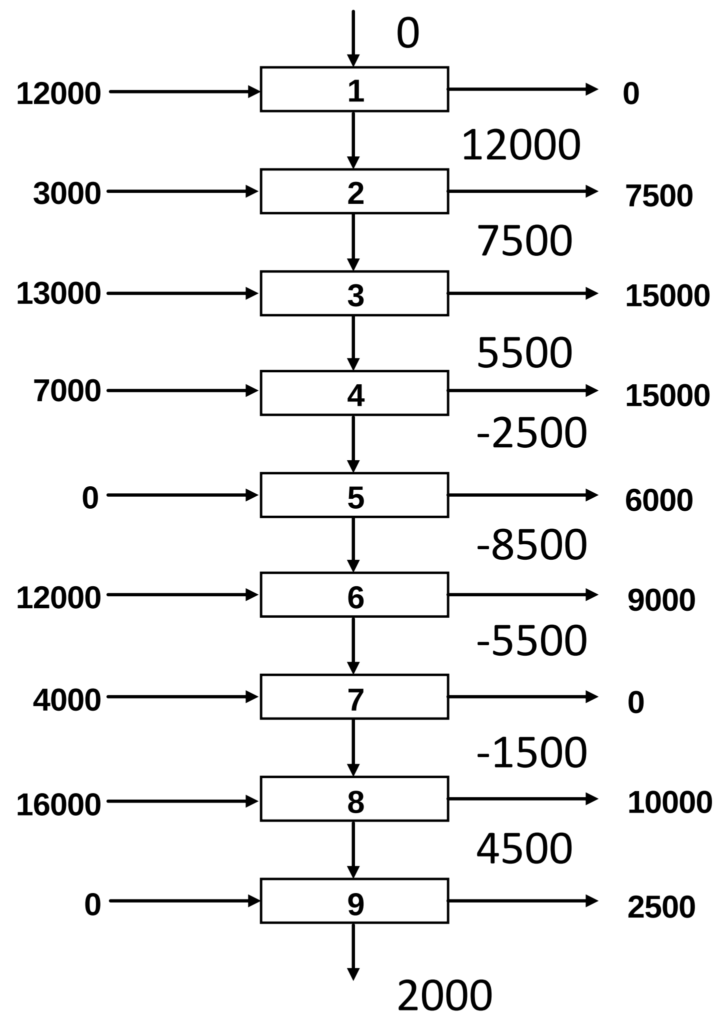
- Next, the total values from the exchangeable heat load tables are added to the cascade diagram
- Hot stream loads enter on the left, cold stream loads exit on the right



Cascade Diagram

- Now, by subtracting an interval's cold load from the hot load, and adding the resulting value to the residual from the previous stage we get the residual value for the subsequent stage
- $r_i = HH_i - HC_i + r_{i-1}$

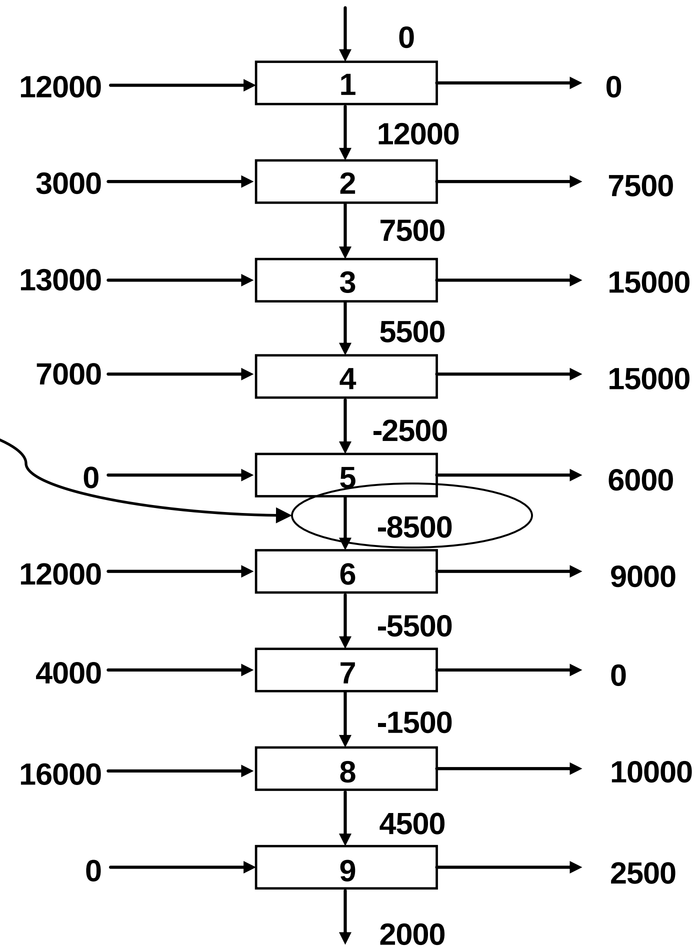
[illegible]



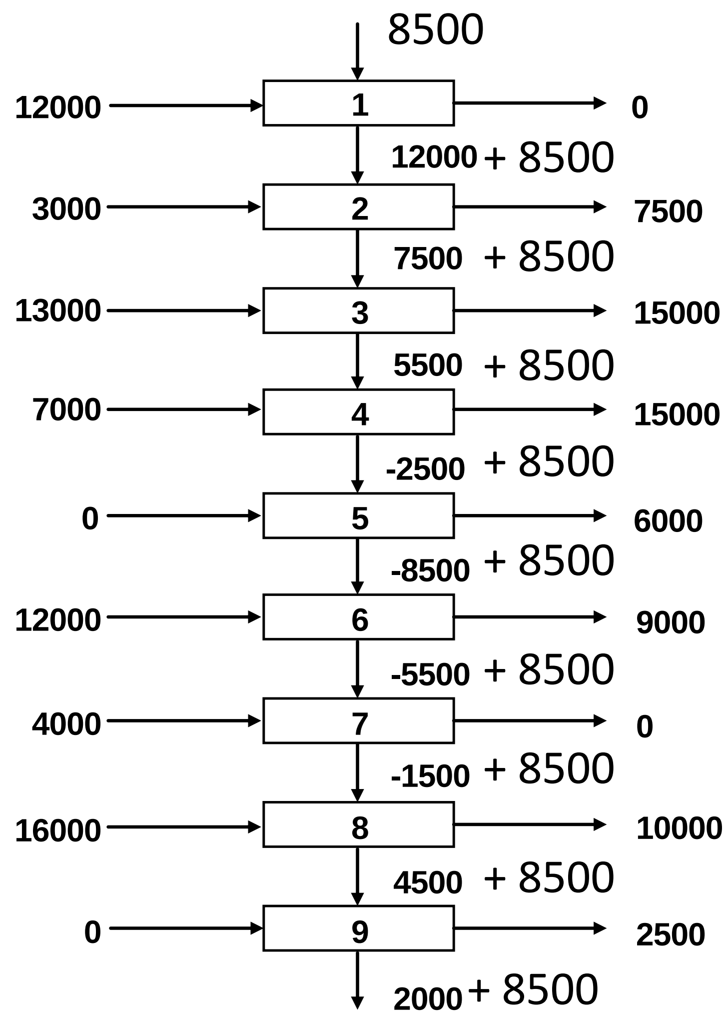
Thermal Pinch Point

- The thermal pinch point occurs at the largest negative number

- The absolute value of this number is now added in at the top to cascade through



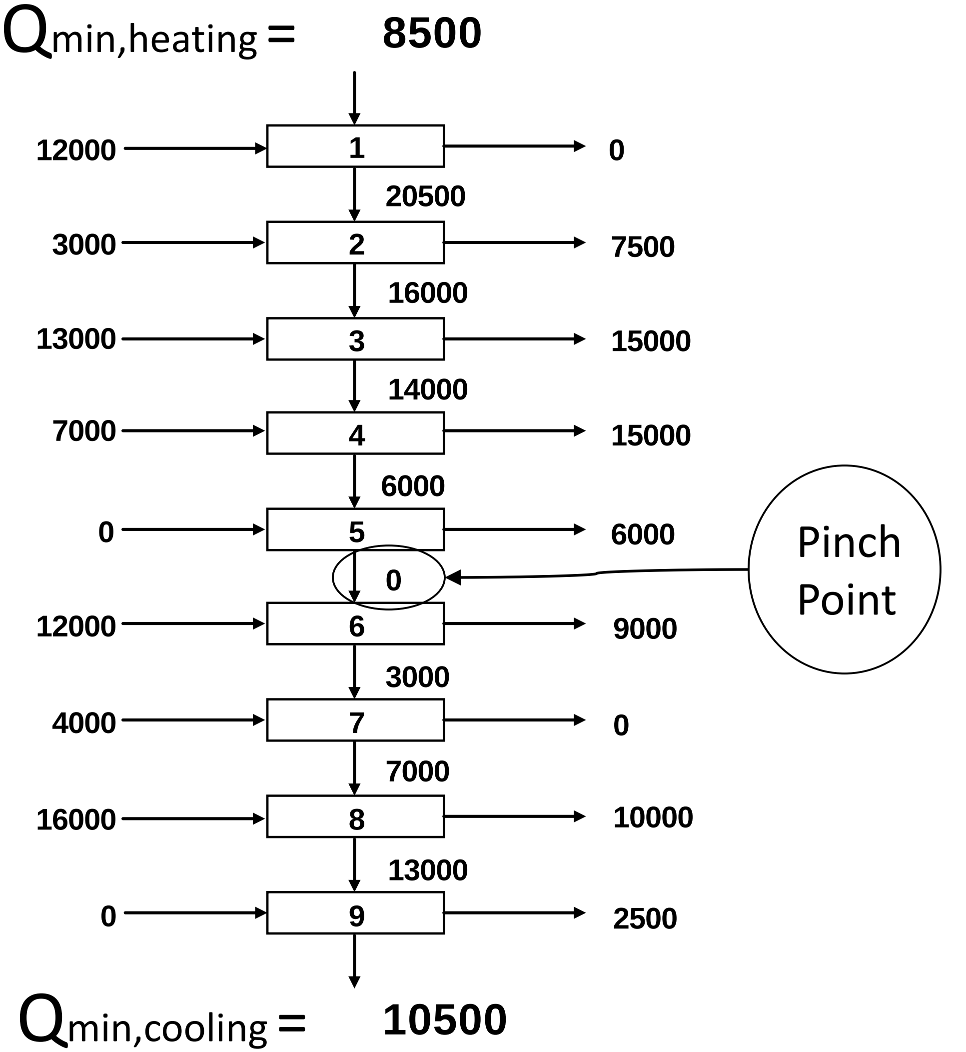
Revised Cascade Diagram



Revised Cascade Diagram

- We now have the final revised cascade diagram
- It can be seen that by adding additional energy at the top, it will cascade through and also be present at the bottom

$Q_H + Q_C = Q_{H,min} + Q_{C,min} + \underline{\mathbf{2\alpha}}$!



Optimized Heat Integration

- The heat exchange network is now fully optimized
- Total required utilities are minimized
  - Minimum cooling utility, $Q_{C,min}$ = 10,500 kW
  - Minimum heating utility, $Q_{H,min}$ = 8,500 kW
  - Minimum total utilities = $Q_C + Q_H$ = 19,000 kW
- As expected, these values are the same as obtained by using the graphing method