

CHE 551 Advanced Topics In Chemical Engineering

**Energy
Optimization Using
Pinch Analysis**

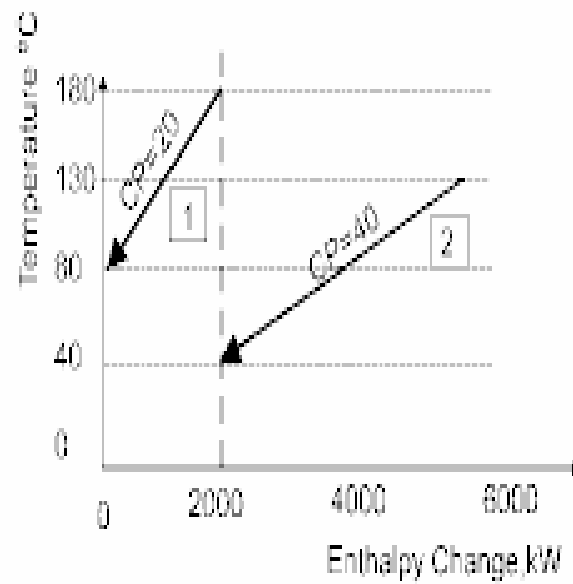
Lecture 5

Dr. Abdulrahman Al-Rabiah

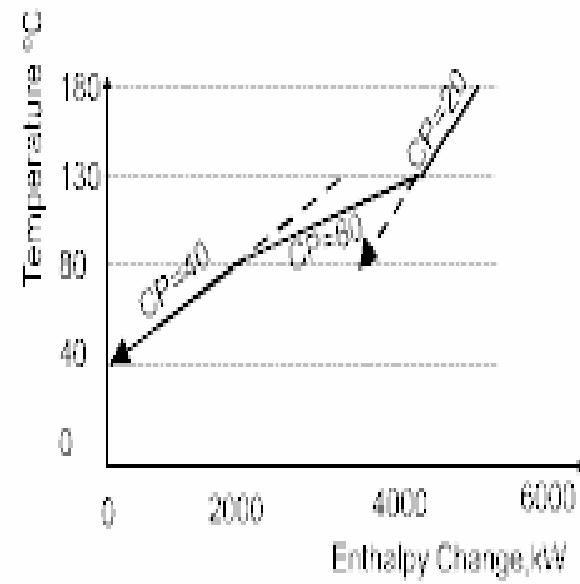


Homework 1

construction of composite curves



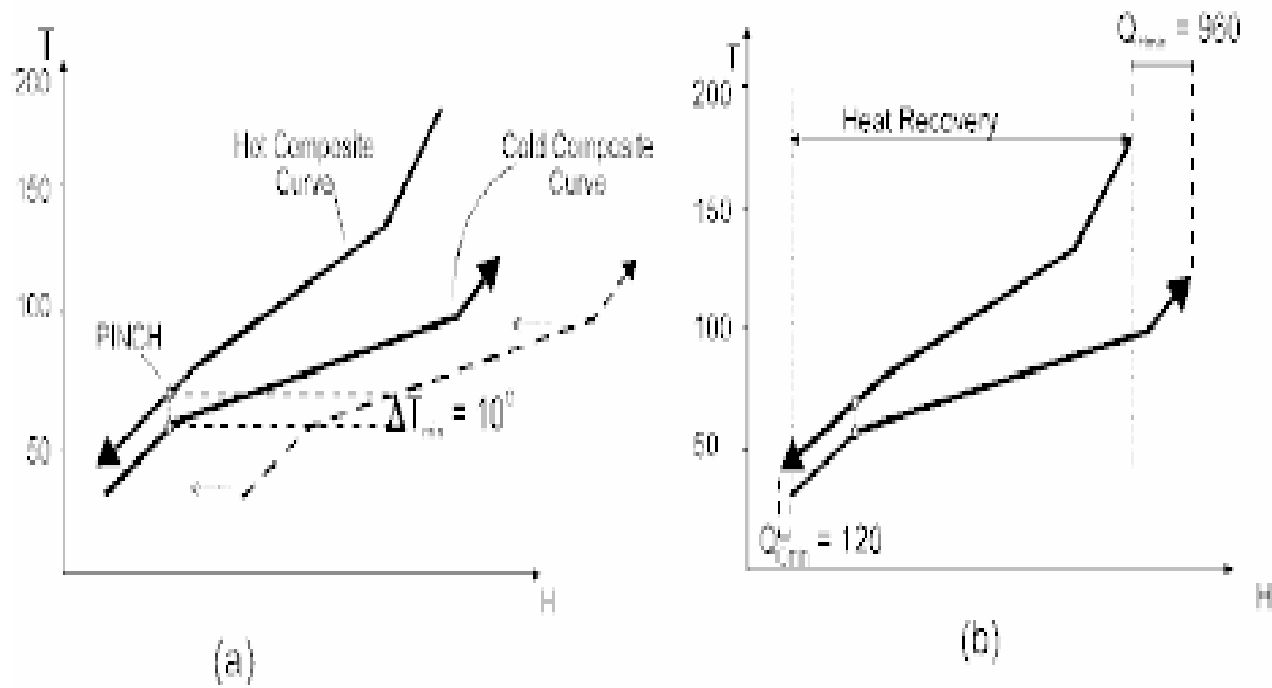
(a)



(b)

Homework 1

Determining the energy targets



Heat Exchanger Network Design for Maximum Energy Recovery

- The heat exchanger network design procedure is based upon pinch analysis principles and is known as the *Pinch Design Method*.
- The task is to match the hot and cold process streams connecting unit operation systems with each other or with external utilities in a heat exchanger network to satisfy the energy targets.

Heat Exchanger Network Design

- The pinch design method utilizes the concept of minimum energy targets to design the heat exchanger network. This is performed on the principle of designing each system above and below the pinch separately.
- The first step in this method requires development of a design *grid diagram* showing all the process streams.

Heat Exchanger Network Design

- It should be noted that the region near the pinch is the most constrained region and generally has the smallest temperature difference between the hot and cold streams.
- For this reason, it is easier to start from the pinch and work towards a region where there is greater freedom rather than in the opposite direction. Therefore, ***[the design of the network should start from the pinch and then move away to satisfy the pinch rules that were discussed previously].***

The pinch design method

- CP inequality
(This rule is used to select the streams that should be matched first for heat exchange).
- The heat capacity flow-rate (CP) of the stream leaving the pinch needs to be greater than the CP of stream approaching the pinch, or

$$CP_{out} \geq CP_{in}$$

The pinch design method

CP inequality

- Above the pinch, it is necessary to observe the inequality criterion:

$$CP_{hot} \leq CP_{cold}$$

- Below the pinch, the necessary criterion is:

$$CP_{hot} \geq CP_{cold}$$

The pinch design method

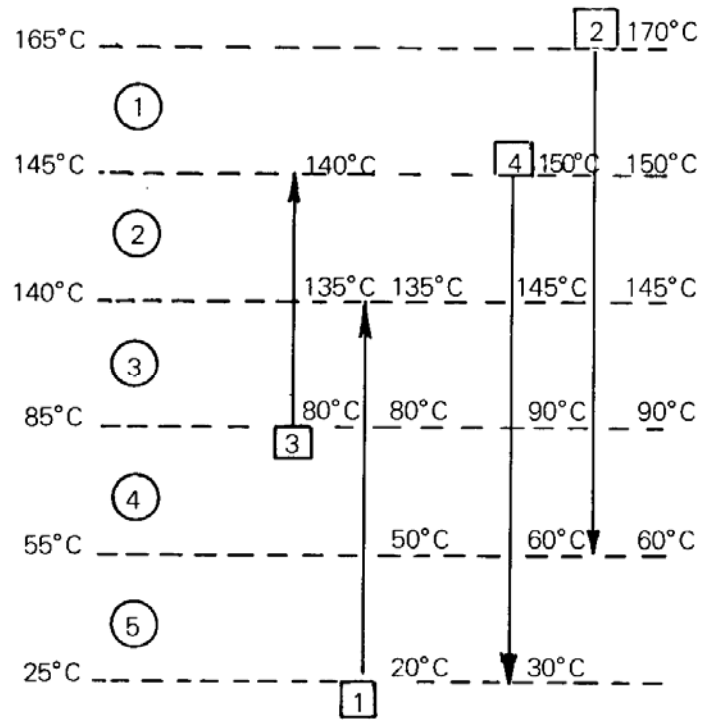
- To satisfy the CP inequality rule, some stream splitting may be required.

Example

Stream No. And Type	CP (kw/°C)	T_s (°C)	T_t (°C)
(1) Cold	2	20°	135°
(2) Hot	3	170°	60°
(3) Cold	4	80°	140°
(4) Hot	1.5	150°	30°

$$\Delta T_{\min} = 10^\circ\text{C}$$

Temperature Interval Analysis



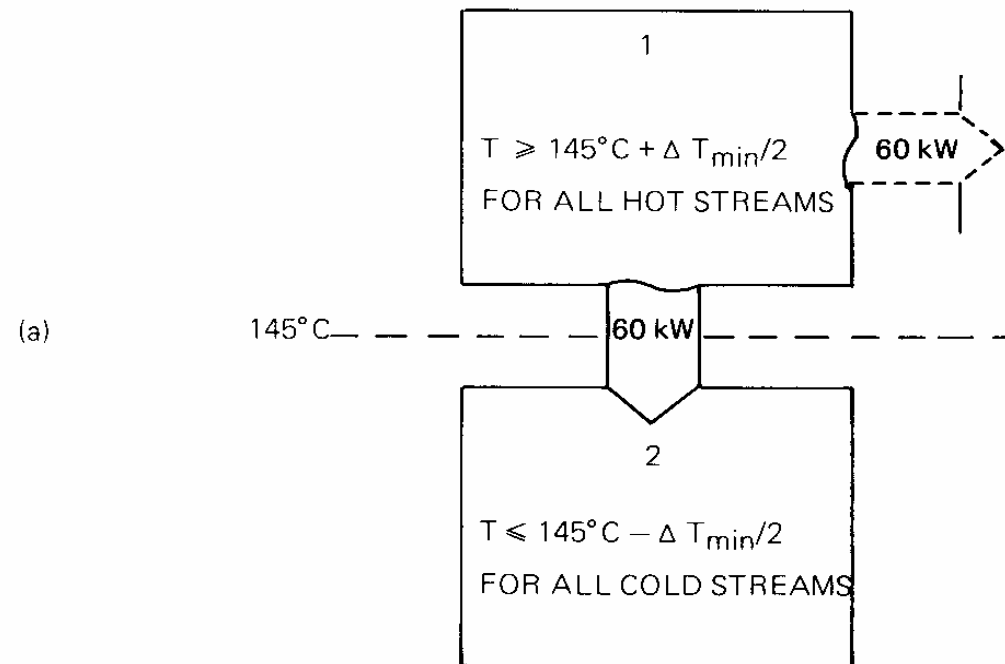
(a)

Temperature Interval Analysis

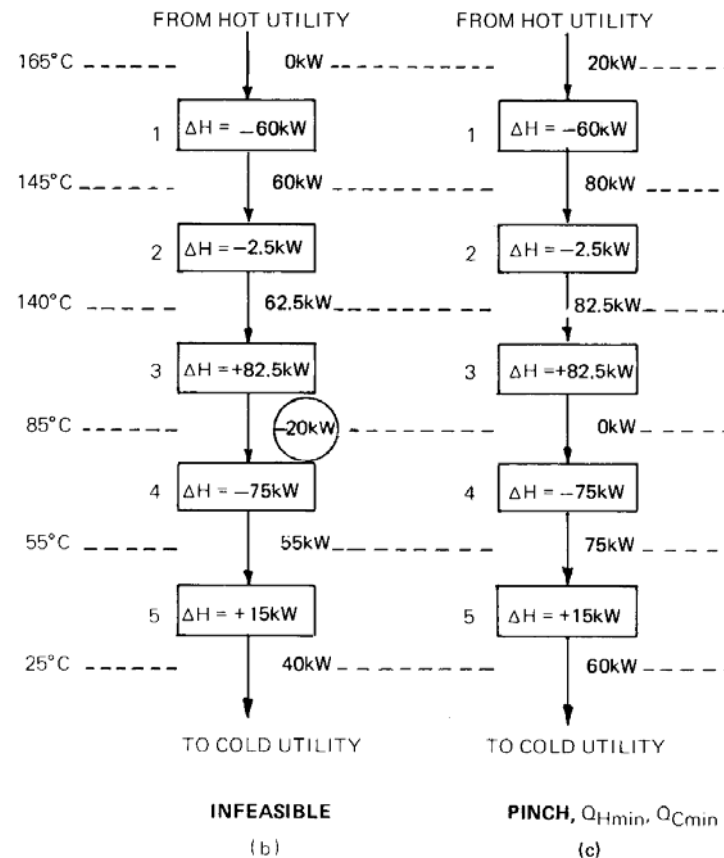
	INTERVAL No. i	$T_i - T_{i+1}$ (°C)	$\Sigma CP_{\text{cold}} - \Sigma CP_{\text{hot}}$ (kW/°C)	ΔH_i (kW)	SURPLUS OR DEFICIT
$T_1 = 165^\circ\text{C}$	1	20	-3.0	-60	SURPLUS
$T_2 = 145^\circ\text{C}$	2	5	-0.5	-2.5	SURPLUS
$T_3 = 140^\circ\text{C}$	3	55	+1.5	+82.5	DEFICIT
$T_4 = 85^\circ\text{C}$	4	30	-2.5	-75	SURPLUS
$T_5 = 55^\circ\text{C}$	5	30	+0.5	+15	DEFICIT
$T_6 = 25^\circ\text{C}$					

(b)

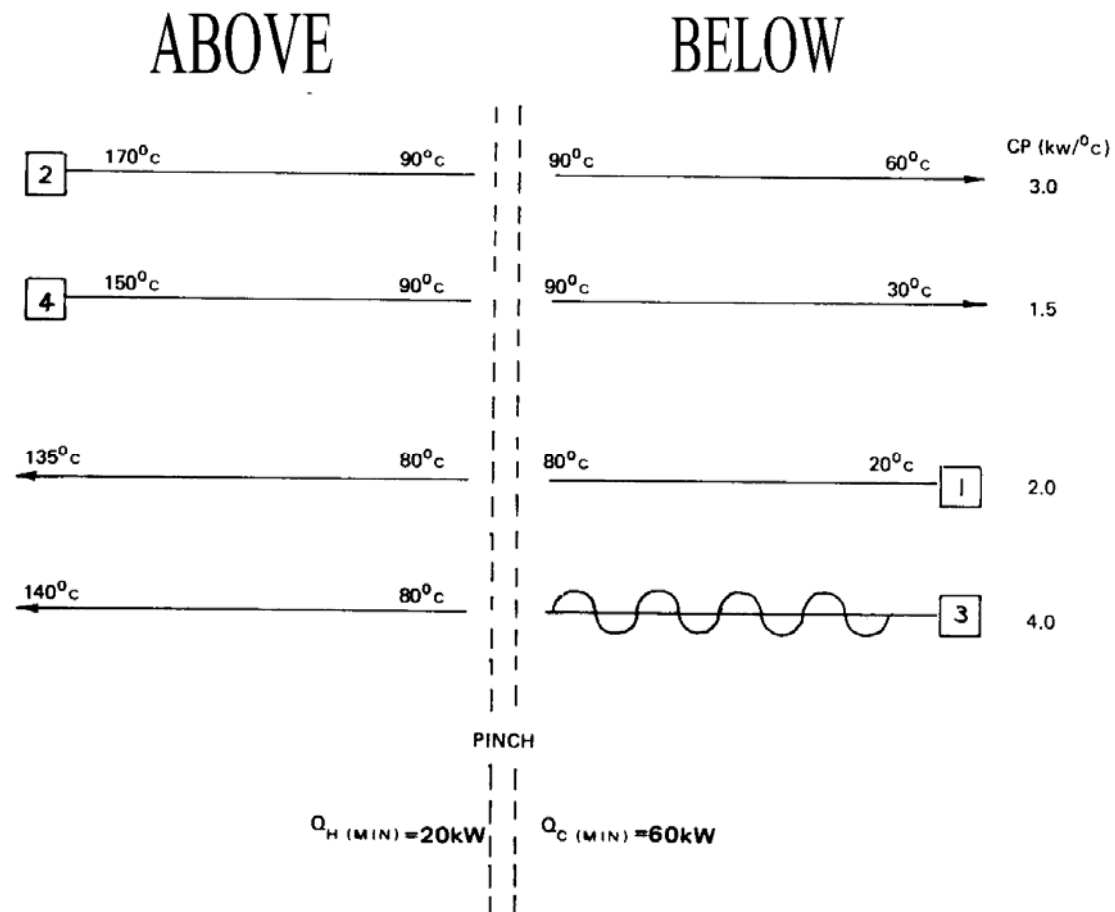
The Heat Cascade Principle – Target Prediction by “Problem Table” Analysis



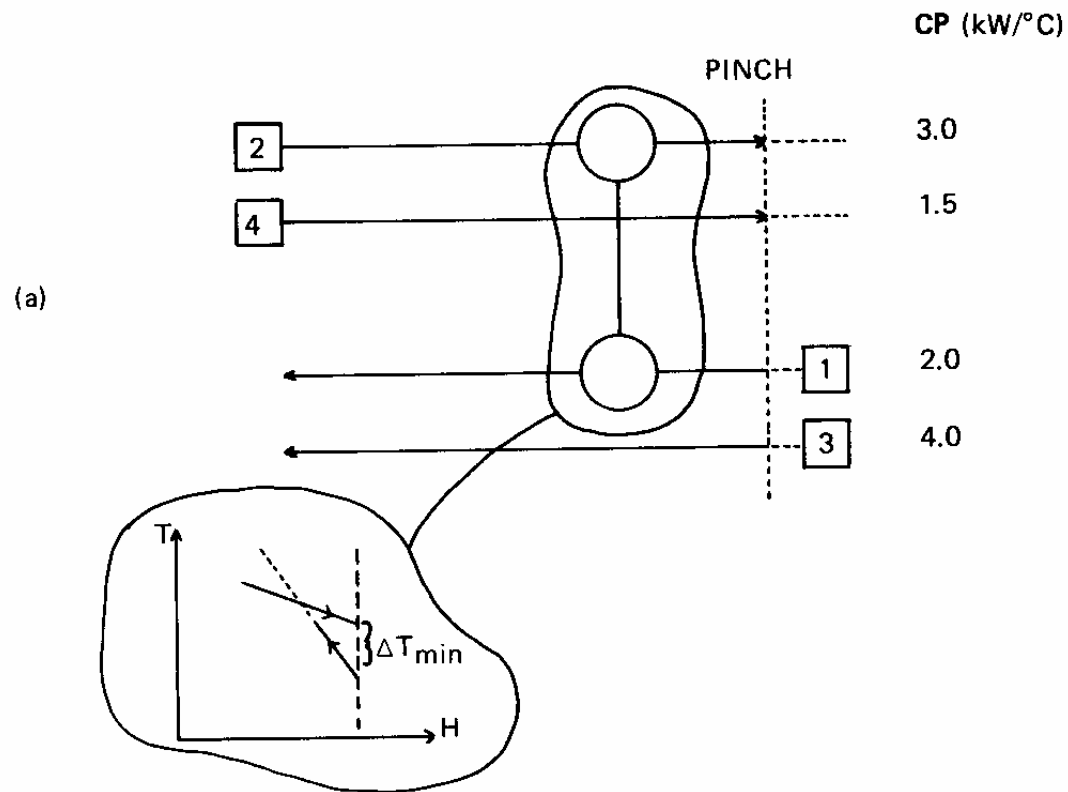
The Heat Cascade Principle – Target Prediction by “Problem Table” Analysis



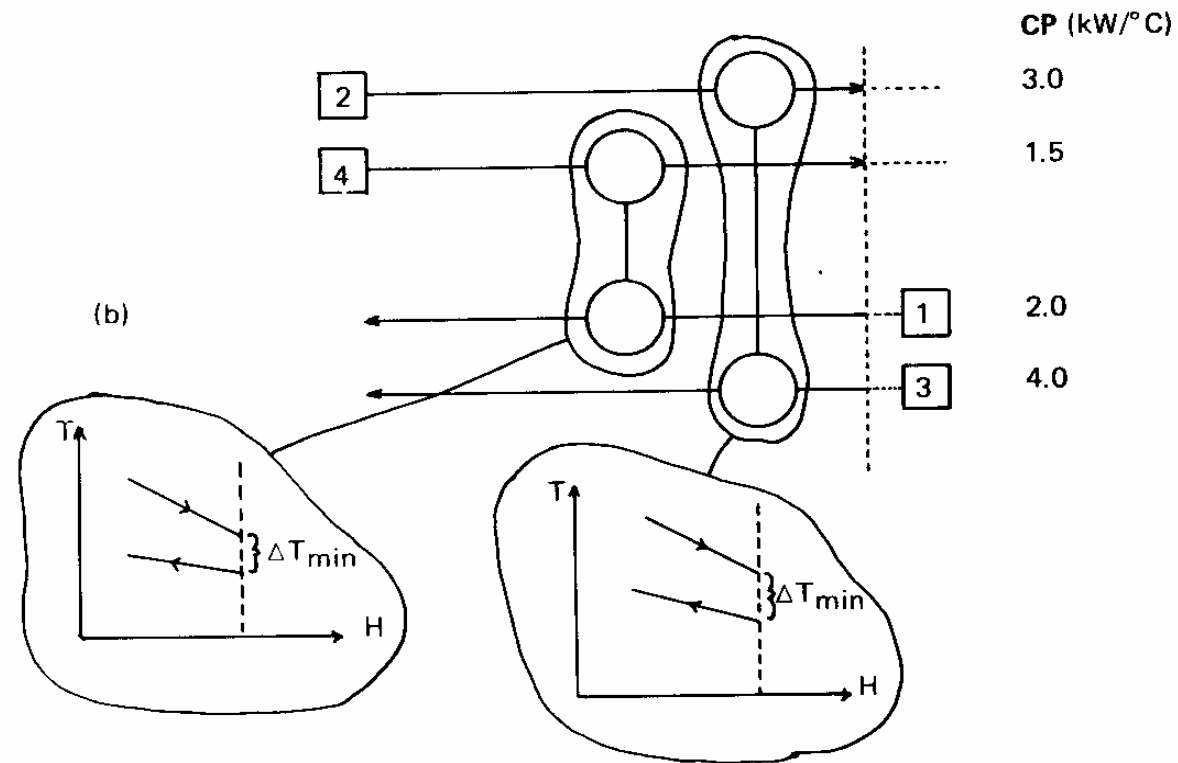
Example Problem Stream Data, Showing Pinch –Grid diagram-



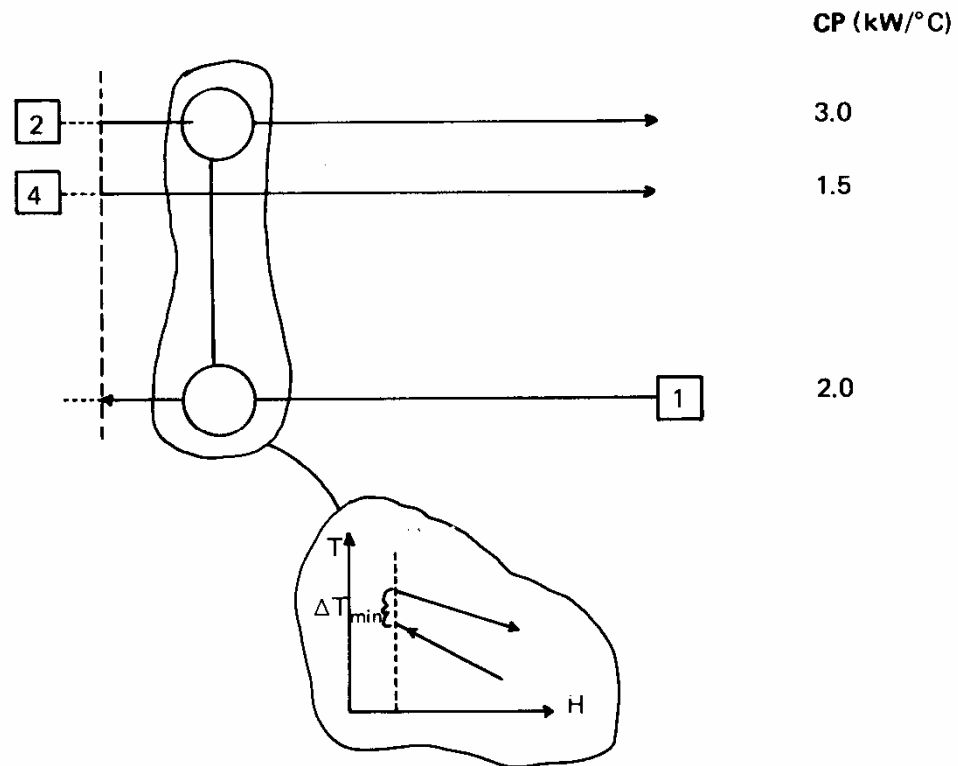
Example Problem Hot End Design



Example Problem Hot End Design

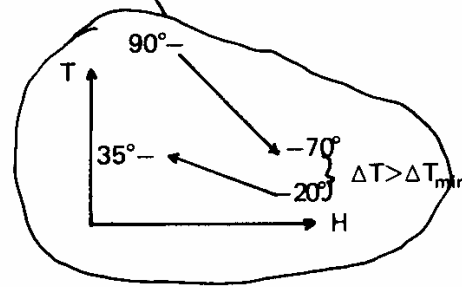
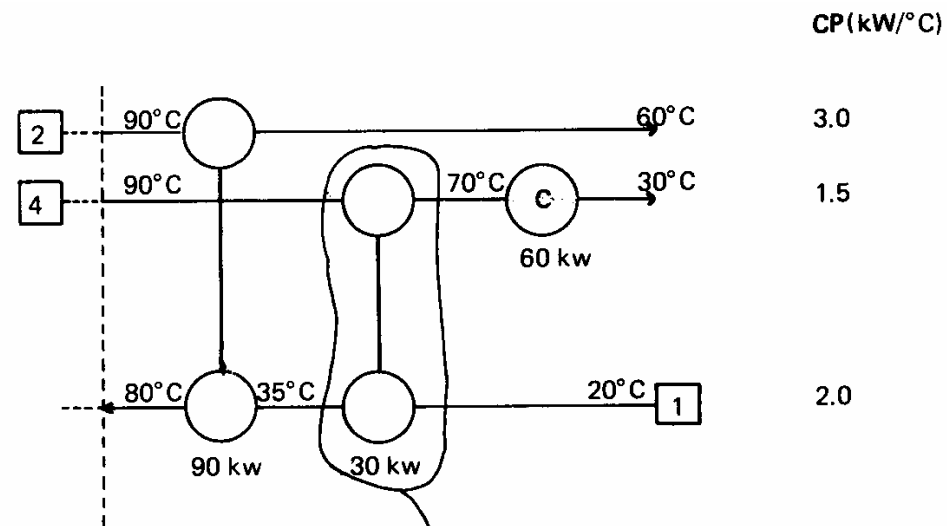


Example Problem Cold End Design



(a)

Example Problem Cold End Design



(b)

Example Problem Completed Design

