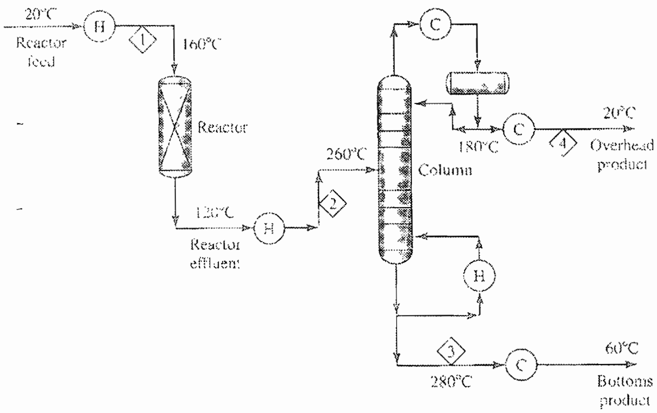
CHL 701: Process Engineering – MAJOR Examination

Date: 27/11/06 Open Book / Notes Duration = 2 hrs Marks = 30

Refer to the Process flow diagram in the figure. The thermal data and mass flow rates for the streams are mentioned in the table, as well:



Stream Number	Stream description	Temperature interval, °C		Heat capacity rate, kJ/(s·°C) $CP = \dot{m}C_p$		Enthalpy change rate, kJ/s $CP(T_{out} - T_{in})$
Streams to be heated		In	Out			
1	Reactor feed	20	160	50		7,000
2	Reactor effluent	120	260	55		7,700
					Total	14,700
Streams to be cooled						
3	Bottom product	280	60	30		−6,600
4	Overhead product	180	20	40		−6,[illegible]
					Total	−13,000

The reboiler temperature is too high for exchange with other streams. Therefore, a hot oil utility stream at 320°C is available for providing heat to the reboiler, which is to be cooled to 310°C upon exchange with the bottoms coming at 280°C. The cooling water utility available for heat exchange with the condenser is at 10°C. After heat exchange with the overheads, its temperature must not be greater than 20°C, so that it can be used effectively for cooling in other parts of the process. At this point, with reflux ratios not known, please do not try to integrate the condenser and reboiler into the process, yet. *The cost of the hot oil is $2.25/GJ and that of the cooling water being $ 0.25/GJ.*

Based on the above diagram for 4 streams S-1 to S-4, carry out the following tasks:

1. Considering the min. temperature differential for any heat exchange as 10°C, design a HEN for maximum energy recovery. Show the following –
    a. Cascade Diagram
    b. T-H diagram, composite [6]
2. What is the Pinch temperature in this process? [1]
3. Keeping in mind the heuristics in Pinch analysis, draw the complete HEN above and below the pinch, and thereby evaluating the total number of heat exchangers. [5]
4. For the above case, evaluate the total heat loads to be met by external utilities, and the total cost of the utilities. [3]
5. Calculate the areas required for the heat exchangers (U = 0.3 W/m^2 s °C, SS, Floating head type), and using the data in the Appendix, compute the total cost of the heat exchangers. [5]
6. Examine the HEN for any loops, and redesign the HEN for minimum number of heat exchangers. From this new design, evaluate the number of heat exchangers, the cost, and the total money spent on utilities. [8]
7. What are your suggestions, regarding the operation of the distillation column, for the minimum utility/ max. energy recovery design. [2]