BIRLA INSTRITUTE OF TECHNOLOGY & SCIENCE, PILANI, PILANI CAMPUS
CHEMICAL ENGINEERING DEPARTMENT

Course Title: Process Design Principles - I (CHE F314)

Mid-Semester Test (Closed Book)

Marks: 90 **Date: 03/11/22** **Time: 90 minutes**

Note: Make suitable assumptions by clearly stating them, if necessary. Write all steps clearly.

1. **(7+5+3 = 15 Marks)**

Cumene ($C_6H_5C_3H_7$) is manufactured by reacting benzene (C_6H_6) with propylene (C_3H_6) in a fixed-bed catalytic reactor. A gas stream containing butane and propylene and a liquid stream containing essentially pure benzene are fed to the reactor. Fresh benzene and recycled benzene (both at 77^0F) are mixed and passed through a heat exchanger where they are heated by the reactor effluent before being fed to the reactor. The reactor effluent enters this exchanger at 400^0F and leaves at 200^0F. The pressure in the reactor is sufficient to maintain the effluent stream as a liquid. After being cooled in the heat exchanger, the reactor effluent is fed to a distillation column. All of the butane and unreacted propylene are removed as overhead products from the column, and the cumene and unreacted benzene are removed as bottom products and fed to a second distillation column where they are separated. The benzene leaving from the top of the second column is recycled and mixed with the fresh benzene feed.

Show the following hierarchy of flow sheets:

(a) General structure
(b) Recycle structure
(c) Input-Output structure

2. **(8+25+1+4+12 = 50 Marks)**

For the problem given with minimum approach temperature difference, ΔT_{min} = 10 ^oC, carry out the Energy Integration Analysis using Pinch Technology by determining the following:

(a) Hot and cold composite curve data
(b) Hot end design & cold end design
(c) Heat exchanger network for the maximum energy recovery (MER)
(d) Identification of loops.
(e) Break only first loop as per heuristic and restore ΔT_{min} as and when there is a violation.

Stream No	Condition	FC_p (kW/^oC)	h (kW/m^2 ^oC)	Source Temperature (^oC)	Target Temperature (^oC)
1	Hot	30	0.15	180	75
2	Hot	40	0.1	240	60
3	Cold	35	0.2	40	230
4	Cold	20	0.1	120	300

Pinch temperature is 175 ^oC (based on average). The minimum hot and cold utility requirements are 2300 and 2400 kW respectively.

3. **(8+4+13 = 25 Marks)**

A viscose fiber manufacturing unit releases 5,00,000 L/h of effluent steam containing 450 mg/L of Zinc [Zn(II)]. The pretreatment cost of effluent before release is Rs. 0.0001 per liter. The market price for zinc is Rs. 29 per kg. It is proposed to recover the Zinc from the effluent stream. As a Design Engineer, you need to answer the following:

(a) Whether the proposed recovery of Zn is an economically viable option? Justify your answer based on the economic potential of the process.
(b) What are the methods available for the recovery of Zn from effluent streams?
(c) Which method will be the most feasible one and why? Also, develop the flow sheet for the same with proper justification.

ALL THE BEST