PROCESS INTEGRATION
(CHEN 4232)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and <u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Major tasks that have a major impact on the overall properties of a plant are the selection of
(a) Reaction path and reactor(s)
(b) Recycle and separation network
(c) Heat exchanger network and utilities
(d) All of the above.

(ii) In Heat Exchanger Network synthesis it is possible to quantify targets for
(a) Minimum utility consumption
(b) Minimum number of units
(c) Minimum area
(d) All of the above.

(iii) Process Integration
(a) Is limited to the design of new plants.
(b) May involve design of new plants as well as retrofit design.
(c) Is involved only in operation.
(d) None of the above.

(iv) A graphical procedure for network design involving a single pinch is
(a) Composite curve method
(b) Problem Table algorithm
(c) Grand composite curve method
(d) Supertargeting.

(v) Above the "pinch point", for MER network design
(a) Utility cooling can be used
(b) Utility heating can be used
(c) Both can be used
(d) None can be used.

(vi) A numerical procedure for network design involving a single pinch is
(a) Composite curve method
(b) Problem Table algorithm
(c) Grand composite curve method
(d) Supertargeting.

(vii) "Threshold problem" involves
(a) Multiple utilities
(b) No utility target at one end
(c) Area targeting
(d) Identifying paths.

(viii) Steam turbines in a cogeneration plant operate on
(a) Carnot Cycle
(b) Diesel Cycle
(c) Rankine Cycle
(d) Vapour Compression Cycle.

(ix) The performance of a heat pump is expressed by its
(a) Power requirement
(b) COP
(c) Inlet temperature only
(d) Exit temperature only.

(x) A feasible ΔT_{cont} value accepted in industrial practice for liquid streams is
(a) 5℃
(b) 10℃
(c) 15℃
(d) 20℃

Group - B

2. Discuss in details the sequential development of a process structure using onion model and simultaneous development of a process structure based on a *superstructure* of the process. *[(CO1)(Analyse/IOCQ)]*

(6 + 6) = 12

3. Discuss in details the different stages involved in the total design effort for a Heat Exchanger Network (HEN) and briefly describe the principle involved in the Pinch Analysis used in HEN synthesis. *[(CO1)(Analyse/IOCQ)]*

12

Group - C

4. (a) What is the logic behind using ΔT_{cont} in pinch analysis? *[(CO1)(Analyse/IOCQ)]*

(b) For the following data, plot the hot composite curve on a graph paper:

Table 1

Stream number	Stream type	CP (kW/℃)	T_S (℃)	T_T (℃)
1	Cold	2	20	135
2	Hot	3	170	70
3	Cold	4	80	140
4	Hot	1.5	150	30

[(CO1)(Apply/IOCQ)]

3 + 9 = 12

5. For the data given in table 1, perform pinch analysis based on a ΔT_{min} of 10℃ and a pinch temperature of 90℃ for hot stream and 80℃ for cold stream. Determine the number of exchangers, heaters and coolers and the total heating and cooling utility loads. *[(CO2) (Evaluate/HOCQ)]*

(4 + 4 + 4) = 12

Group - D

6. Discuss the significances of "Loops" and "Paths" in optimizing a heat exchanger network. Explain the process of breaking a loop without violating thermodynamic principles. *[(CO3)(Analyze/IOCQ)]*

12

7. Discuss the utility of stream-splitting in pinch analysis, with an example.

[(CO3)(Analyze/IOCQ)]

(4 + 8) = 12

Group - E

8. Enumerate a suitable MER network design method for a crude preheat train.

[(CO4)(Evaluate/HOCQ)]

12

9. Explain the process flow in an aromatics plant with a diagram. *[(CO4)(Analyse/IOCQ)]*

(8 + 4) =12

Cognition Level	*LOCQ*	*IOCQ*	*HOCQ*
Percentage distribution	*0*	*75*	*25*

Course Outcomes (CO):

After completing this course students will be able to:

1. Perform pinch analysis on a given Heat exchange system to identify non-optimal arrangements.
2. Design a Heat Exchanger Network (HEN) for a given heat exchange problem.
3. Analyze and optimize a HEN with respect to cost, energy requirement, area requirement etc.

4. Design energy-integrated process systems for distillation, chemical reaction, evaporation, refrigeration and cogeneration.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*