Master of Mechanical Engineering Examination 2019
Second Semester
HEAT EXCHANGER

Full Marks: 100 **Time: 3 hours**

Answer any ***four*** questions. Assume any unfurnished data suitably.

1. a) Discuss the suitability of the LMTD-F_T approach and the ε-NTU approach in the context of 'Rating' and 'Sizing' of heat exchangers.
   b) Draw the variation of temperature of two fluids in a cross flow heat exchanger, with both fluids unmixed, and a 1-2 shell and tube heat exchanger..
   c) Find an expression for the effectiveness of a parallel-flow heat exchanger in terms of NTU and ratio of heat capacity of the fluids. **(25)**

2. a) What is 'temperature cross' in a multi-pass heat exchanger?
   b) Discuss how the following can be obtained using the F-θ-NTU-P chart
      i) To calculate mean temperature difference; inlet and outlet temperatures are known.
      ii) To calculate the heat exchanger surface area; inlet and outlet temperatures and the overall heat transfer coefficient are known.
      iii) To calculate the outlet temperatures; total surface area, overall heat transfer coefficient, stream flow rates, specific heat capacities and inlet temperatures are given.
   c) An oil cooler is fed with an oil that has specific heat of 2 kJ/kgK, flow rate of 10 kg/s and inlet temperature of 90 ^{o}C. The cooling stream is treated cooling water that has a specific heat of 4.2 kJ/kg/K, flow rate of 20 kg/s and inlet temperature of 15 ^{0}C. Assuming a total heat transfer area of 200 m^2 and an overall heat transfer coefficient of 150 W/m^2K, calculate the outlet temperatures of oil for a one shell pass and two tube pass heat exchanger. **(25)**

3. Find an expression for the LMTD correction factor of a one-shell pass two-tube pass heat exchanger in terms of the inlet and outlet temperatures of the hot and cold fluids. **(25)**

4. Consider a process plant handling three hot streams and three cold streams. The stream details are given below.

Stream Number	Hot or Cold	$\dot{m}c_p$ (W/K)	Inlet Temperatures (^{0}C)	Outlet Temperatures (^{0}C)
1	Hot	1200	270	40
2	Hot	8000	100	60
3	Hot	2800	180	50
4	Cold	5000	120	220
5	Cold	3200	80	170
6	Cold	2000	60	140

Plot the composite curves on temperature-enthalpy diagram for the hot and the cold streams. Hence, compute the minimum hot and cold utilities and maximum practicable heat exchange for a pinch of 10 ^{0}C. **(25)**

5. a) Explain the method of selection of the appropriate type of heat exchanger based on operating conditions and economic considerations.

b) A light hydrocarbon vapour is to be condensed under saturation conditions at a temperature of 120 ^0C. It enters the condenser a saturated vapour and leaves as saturated condensate. It is flowing at a rate of 300 kg/s and has a latent heat of 200 kJ/kg. The coolant is treated cooling water entering at 20 ^0C and leaving at 50 ^0C. Assess the alternative use of shell and tube and double pipe heat exchangers for this duty and carry out an approximate cost comparison using the *C*-value method to select the most economical one.
Discrete *C*-values are given in the following table.

Double pipe heat exchanger	$\frac{\dot{Q}}{\Delta T_M}$ (W/K)	30,000	1,00,000	1,000,000
	C-value [Re/(W/K)]	40.0	30.0	30.0
Shell and tube heat exchanger	$\frac{\dot{Q}}{\Delta T_M}$ (W/K)	30,000	1,00,000	1,000,000
	C-value [Re/(W/K)]	25.0	16.0	10.0

(25)

6. a) Make neat sketches of the following type of heat exchangers and mention the suitability and limitation of each of them, if any, in specific applications:
   i) Gasketed plate heat exchanger
   ii) Spiral heat exchanger
   iii) Rotary regenerator

   b) Discuss the following for a shell and tube heat exchanger
   (i) Two different types of tube pitch layout
   (ii) Two different types of baffle design **(25)**