(4 Hours) **[Total Marks : 100**

N.B. (1) Question No. **1** is **compulsory**. Attempt any **three** from remaining **five** questions.
(2) Use of standard data book and **graphs is permitted**.
(3) Assume **suitable data** if **necessary** with **justification**.

page (1) M.E(M) Thermal - II Rev Design of Heat Exchanger 18/5/09 MASTER

1. (a) Name the specific heat exchanger construction type (with appropriate reasons) that may be used in each of the following applications :– **10**
   (i) Power condenser
   (ii) Milk pasteurizing
   (iii) Automobile radiators
   (iv) Air preheater in power plant
   (v) Marine oil coolers.

   (b) Discuss a general design methodology of heat exchanger with a flow chart representing the sequence of various design activities. **10**

   (c) For a two fluid counter flow arrangement, show a general variation of temperature along the length of heat exchanger (through sketches) for the following cases. **5**
   (i) both fluid undergoing temperature change,
   (ii) hot fluid is cooled from superheated to sub-cooled state,
   (iii) cold fluid is heated from saturated to superheated state
   (iv) both fluid undergoing phase change (Clearly state if any assumption is made)

2. (a) What does the effectiveness of a heat exchanger represents? On what factors do it depends ? Can it be greater than one? Under what conditions is the effectiveness-NTU method definitively preferred over the LMTD method in heat exchanger analysis? **10**

   (b) Derive effectiveness-NTU relation for a parallel flow heat exchanger. **15**

3. (a) Explain the methodology of heat exchanger design in brief **10**

   (b) A shell and tube heat exchanger is designed to heat water from 40°C to 60°C with a mass flow rate of 20,000 kg/h. Water at 180°C flows through the tubes with a mass flow rate of 10,000 kg/h. The tube have a inner diameter of 20 mm, the Reynolds number 10000. $U = 450\ W/m^2.K$ Calculate the heat transfer rate of the heat exchanger and the exit temperature of the fluid. If the HX is the counter flow with one tube and one shell pass, determine the following using ε : -NTU method: **15**
   (i) The outer heat transfer area,
   (ii) The velocity of fluid through the tubes
   (iii) The cross-sectional area of the tube
   (iv) The number of tubes and the length of the heat exchanger.

$$\text{Where, } NTU = \frac{1}{(1+C^{*2})} \ln\left[\frac{2-\varepsilon\left[1+C^{*}-(1+C^{*2})^{1/2}\right]}{2-\varepsilon\left[1+C^{*}+(1+C^{*2})^{1/2}\right]}\right]$$

4. (a) Discuss (with a sketch) the constructional features of a shell and tube heat exchanger with a focus on the following. **10**
   (i) shell, (ii) tube and tube bundles, (iii) tube passes, (iv) tube layout and (iv) baffles.

   (b) A shell and tube heat exchanger is selected for a particular application with following parameters : **15**
   Shell side fluid: Hot water, Inlet and outlet temp: 67°C and 53°C.
   Tube side fluid: Water at average temperature of 28.5°C.

Shell internal diameter :	0.39 m
Number of tubes :	124
Tube diameter :	od : 19mm, id: 16mm
Tube material :	$k=60\ W/m^2\ K$
Baffle spacing :	0.25
Baffle cut :	25%
Tube layout :	Square
Pitch size :	0.024 m
Number of tube passes	2

Estimate shell side and tube side heat transfer coefficient and pressure drop.

Following correlation can be used for shell side :

$$Nu = 0{\cdot}36\ Re^{0.56}\ Pr^{0.33}$$

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1810 Mechl. E(M) Thermal-II Rev Design of Heat Exchanger

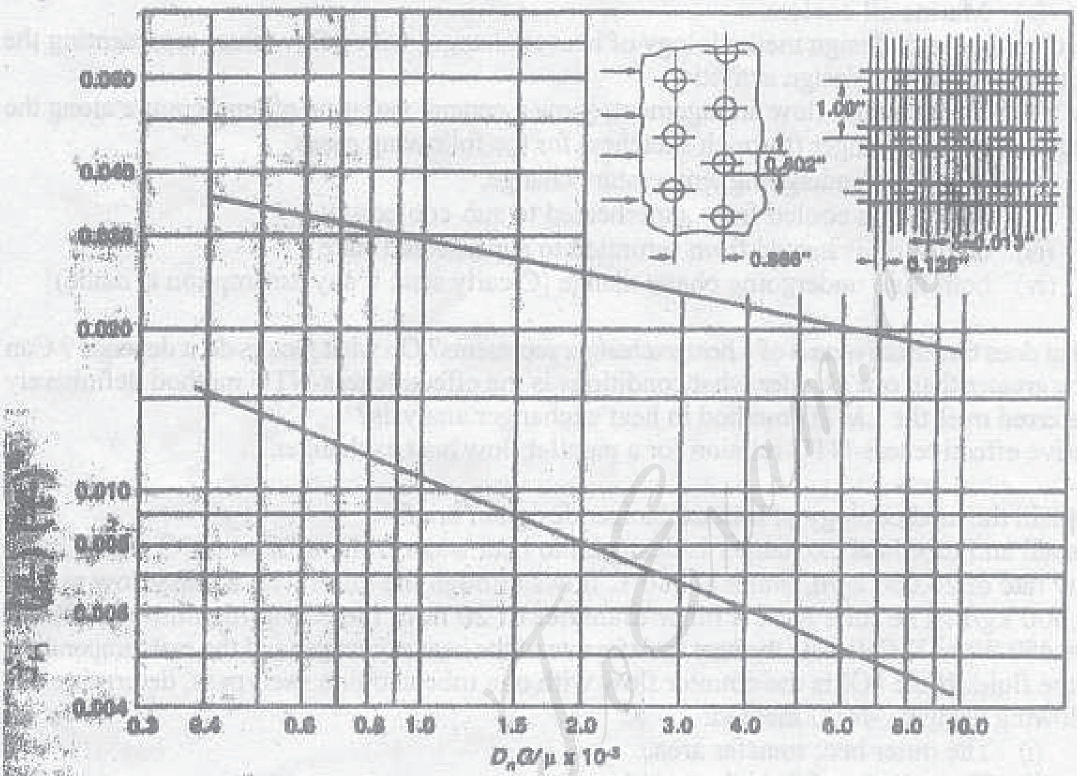
5. (a) Discuss the advantages and limitations of compact heat exchangers. 10

Page 2 (b) Air enters the core of a finned tube heat exchanger of the type shown in **fig.1** at 12 atm and 150°C. The air mass flow rate is 10 kg/s and flow perpendicular to the tubes. The core is 0·5 m long with a 0.30 m^2 frontal area. The height of the core is 0·5 m. Water at 15°C and at a flow rate of 50 kg/s flows inside the tubes. Air side data is given in **fig.1**. For water side data, assume $\sigma = 0.129$, $D_h = 0.373$ cm, and water side heat transfer area/total volume = 138 m^2/m^3 Calculate : 15

(i) The air side and water side heat transfer coefficient,

(ii) Total heat transfer,

(iii) Outlet temperature of air and water.



...eat transfer and friction factor for a circular tube continuous fin heat exchanger. Surface 8.0-3/8 T; tube O.D. = 1.02 cm; fin pitch = 3.15/cm; fin thickness = 0.033 cm; fin area/total area = 0.839; air-passage hydraulic diameter = 0.3633 cm; free-flow area/frontal area, σ = 0.534; heat transfer area/total volume = 587 m^2/m^3. (From Kays, W. M. and London, A. L. [1984], *Compact Heat Exchangers*, 3rd ed., McGraw-Hill, New York. With permission.)

Figure – 1

6. (a) Discuss the important features of plate heat exchanger. 10

(b) The following constructional information is available for a gasketed plate heat exchanger: 15

Chevron angle	45°
Enlargement factor	1·25
Port diameter	15 cm
Plate thickness	0·0006 m
Vertical port distance	1·50 m
Horizontal port distance	0·50 m
Plate pitch	0·0035 m

Calculate :

(i) Mean channel flow gap

(ii) One channel flow area

(iii) Channel hydraulic diameter

(iv) Projected plate area

(v) Effective surface area per plate.