Total No. of Questions :8]

SEAT No. :

P1707

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[4859]-48

B.E. (Mechanical Engg.)

a-INDUSTRIAL HEAT TRANSFER EQUIPMENTS

(2008 Pattern) (Elective - IV) (Semester - II) (402050)

Time : 3 Hours] *[Max. Marks :100*

Instructions to the candidates:

1) ***Question No.1 and No.5 are compulsory. Out of the remaining attempt any two questions from ech section.***
2) ***Answers to the two sections should be written in separate books.***
3) ***Neat diagrams must be drawn wherever necessary.***
4) ***Figures to the right indicate full marks.***
5) ***Use of logarithmic tables, slide rule, Mollier charts, electronic pocket calculator and steam tables is allowed.***
6) ***Assume suitable data, if necessary.***

SECTION - I

Q1) a) A chemical industry produces 200 tons of sulphuric acid per day when running for 24 hours. The acid is cooled in counter flow double pipe heat exchanger from 60°C to 40°C. The cooling medium employed is water, which enters the exchanger at 15°C and leaves at 20°C. The acid flows through the inner pipe, while the water flows through the annulus. The inner and outer diameters of inner pipe are 70 mm and 80 mm respectively, while those of outer pipe are 120 mm and 130 mm respectively. The thermal conductivity of inner pipe material is 46.5 w/m K. Calculate: **[12]**

i) Mass flow rate of water per

ii) Length of heat exchanger

Use the following properties of water and acid at mean bulk temperature:

Property	Water	Acid
$\rho(kg/m^3)$	998.2	1800
$C_p(kJ/kg.K)$	4.18	1.465
$k_f(W/m.K)$	0.598	0.302
$\nu(m^2/s)$	1.006×10^{-6}	6.8×10^{-6}
$R_f(m^2.K/W)$	-	0.0002

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b) A shell and tube heat exchanger must be designed to heat 2.5 kg/s of water from 15 to 85°C. The heating is to be accomplished by passing hot engine oil which is available at 160°C, through the shell side of the exchanger. The oil is known to provide an average convection coefficient of 400 W/m^2 K on the outside of the tubes. Ten tubes pass the water through the shell. Each tube is thin walled, of diameter 25 mm, and makes eight passes through the shell. If the oil leaves the exchanger at 100°C, what is its flow rate? How long must the tubes be to accomplish the desired heating? **[10]**

Take for engine oil C_p = 2350 J/kg K.

For water C_p = 4181 J/kg K, μ=548 x 10^{-6} N.s/m^2, k = 0.643 W/m, Pr=3.56.

Q2) a) Explain the various off-line mechanical cleaning methods used in heat exchanger. **[6]**

b) Explain in details what you understand by flow-induced vibration as referred to shell and tube heat exchanger. **[8]**

Q3) a) Air at 25°C flows over a cross flow car radiator and cools water from 99°C to 60°C. Water flows at the rate of 4 kg/min through a number of separate passages within the heat exchanger. The mass flow rate of air is 14 kg/min. If overall heat transfer coefficient is 80 W/m^2 K. Determine the required heat transfer area and heat exchanger effectiveness. Assume **[8]**

i) Clean and scale free heat transfer surfaces.

ii) Constant specific heat of fluids over given temperatures ranges.

C_p, water = 4186 J/kg K C_p, air = 1006 J/kg K

iii) Overall heat transfer coefficient is constant.

iv) Air is mixed fluid

Given that for cross flow heat exchanger

$\varepsilon=(1/R)\,[1 - \exp\{-R\,(1 - \exp(-NTU))\}]$

Where $R = C_{min}/C_{max}$

b) Explain the classification of plate heat exchanger with their applications.**[6]**

Q4) a) Explain the various types of shell standardized by TEMA. **[8]**

b) Explain Bell's method for sizing of a shell and tube heat exchanger. **[6]**

SECTION - II

Q5) A rotary regenerator, with a rotational speed of 10 rpm is used to recover energy from a gas stream at 250°C flowing at 10 kg/s. This heat is transferred to the air stream at 10°C, also flowing at 10 kg/s. The wheel depth is 0.22 m and diameter 1.6 m, so that its face area is approximately 1.8 m^2. The mass of the matrix is 150 kg with a surface-to-volume ratio of 3000 m^2/m^3, and the mean specific heat of the matrix material is 0.8 kJ/kg K. The heat transfer coefficient for both fluid streams is 30 W/m^2 K. The mean isobaric specific heat of the gas is 1.15 kJ/kg K and that of air is 1.005 kJ/kg K. The flow split gas air = 50%:50%. For counter flow arrangement, calculate the following values: **[18]**

a) The regenerator effectiveness.

b) The rate of heat recovery and the outlet temperatures of air and gas.

c) The rate of heat recovery and the outlet temperatures of air and gas if the rotational speed of wheel is increased to 20 rpm.

d) The rate of heat recovery and the outlet temperatures of air and gas if the rotational speed of wheel is reduced to 5 rpm.

Q6) a) In a large steam power plant, a shell and tube type steam condenser is employed which has the following data: **[12]**

Heat exchange rate	:2100Mw
Number of shell passes	:one
Number of tubes (thin walled)	:31500, each executing two passes
Diameter of each tube	:25 mm

Mass flow rate of water through tubes :3.4 x 10^4 kg/s

The condensation temperature of steam :50°C

(The steam condenses on the outer surface of the tubes)

The heat transfer coefficient on the steam side : 11400 $W/m^{2o}C$

The inlet temperature of water :20^oC

Using LMTD correction factor method and NTU method, calculate:

i) The outlet temperature of cooling water and

ii) The length of tube per pass

Take the following properties of water (at $t_{bulk} = 27^oC$)

C_p=4.18 kJ/kg ^oC, μ= 855 x 10^{-6} Ns/m^2, k=0.613 W/m ^oC and Pr = 5.83.

The thermal resistance of tube material and fouling effects may be neglected.

b) Explain the method to determine number of shells in shell and tube heat exchanger. **[4]**

Q7) a) A finned tube compact heat exchanger having the core configuration of figure 14. The core is fabricated from aluminium (k=237 W/m K) tubes have an inside diameter of 13.8 mm. In a waste recovery applications, the water flow through the tubes provides an inside convection coefficient of 1500 W/m^2 K, while the combustion gases at 1 atm and 700 K are in cross flow over the tubes. If the gas flow rate is 1.25 kg/s and the frontal area is 0.2 m^2, what is the overall heat transfer coefficient based on gas side? Take fin efficiency as 0.89. **[10]**

b) Write a short note on heat pipe exchanger. **[6]**

Q8) a) Explain the selection criteria of heat exchanger. **[8]**

b) Explain design methodology for heat exchanger with the help of flow chart. **[8]**

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