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M .TECH
TFPE203/ HTPE204

Second Semester M Tech Regular / Back Examination – 2014-15

HEAT EXCHANGER ANALYSIS &DESIGN

Branch: Thermal & Fluid Engineering, Thermal Engineering

Time: 3 Hours
Max marks: 70
Q. Code:T301, T320

Answer Question No.1 which is compulsory and any five from the rest.
The figures in the right hand margin indicate marks.
(steam tables and related charts are allowed in the examination hall)

Q1 Answer the following questions: (2 x 10)

a) State different types of cooling towers used in industrial applications.
b) Explain the physical significance of NTU.
c) For phase change type of counter flow type heat exchangers, mention the relation ship between NTU and effectiveness.
d) Draw the parallel flow type evaporator having length and temperature as x- axis and y- axis respectively.
e) What do you mean by fouling factor? Mention its causes.
f) What is compact heat exchanger? Mention its applications.
g) How TEMA charts are are helpful in design of multiple pass heat exchangers?
h) What is limitation of the LMTD method? How is ε-NTU method is superior to correction factor-LMTD method?.
i) What do you mean by hydraulic diameter and its impact on heat exchanger?
j) How can the flow induced vibration be minimized?

Q2 Explain flow distribution in heat exchangers mentioning the effect of turbulence, friction factor, pressure loss, orifice, flow nozzle, diffusers, bends, baffles, effect of channel divergence and manifolds. (10)

Q3 Given are the heat load to be removed in the cooling tower, the inlet air conditions such as dry and wet bulb temperature (to calculate the inlet air humidity and enthalpy), lower and upper limits for outlet and inlet water temperature, respectively, the minimum approach, the minimum allowable temperature difference, the minimal difference between the dry and wet bulb temperature at each integration interval, and the fan efficiency. (10)

The problem then consists of determining the geometric and operational design parameters (fill type, height and area fill, total pressure drop in the fill, outlet air conditions, range and approach, electricity consumption, water and air mass flow rate, and number of

transfer units) of the counter flow cooling tower.
Mention all the necessary steps for this cooling tower design.

Q4 Water is required to be preheated for a boiler using flue gases from the boiler stack. The flue gases are available at the rate of 0.25 kg/s at 150°C, with specific heat of 1000 J/kgK. The water entering the exchanger at 15°C at the rate of 0.05kg/s is to be heated to 90°C. The heat exchanger is to be reversed current type with once shell pass and four tube passes. The water flows inside the tubes which are made of copper (25 mm inner and 30 mm outer diameter). The heat transfer coefficient at the gas side is 115 W/m^{2}K while the heat transfer coefficient of the water side is 1150 W/m^{2}K. A scale on water side offers an additional thermal resistance of 0.02 m^{2}K/W. Determine (10)

i) overall heat transfer coefficient on the outer tube
ii) appropriate mean temperature difference
iii) required tube length
iv) outer tube temperature and effectiveness if the water flow rate is doubled, giving heat transfer coefficient of 1820 W/m^{2}K?

Q5 a) Explain how charts provided by Kays and London are useful in the design of heat exchangers? (5)

b) Show with neat sketch of temperature distribution for unmixed cross flow heat exchanger and explain it. (5)

Q6 a) Show that for a counter flow heat exchanger (5)

$$\varepsilon = \frac{1-\exp\left[-\mathrm{NTU}\left(1-\mathrm{R}\right)\right]}{1-\mathrm{R}\ \exp\left[-\mathrm{NTU}\left(1-\mathrm{R}\right)\right]}$$

b) In the heat transfer relation Q=UAΔTlm for a heat exchanger, what is ΔTlm called? Derive the expression for counter flow heat exchanger. (5)

Q7 a) What are the various sources of a noise in a heat exchanger? How it can be minimized? (5)

b) Steam enters a counter flow heat exchanger, dry saturated at 10 bar and leaves at 350^{0}C. The mass flow of stream is 800 kg/min. The gases enter the heat exchanger at 650^{0}C and mass flow rate is 1350 kg/min. If the tubes are 300 mm diameter and 3 m long, determine the number of tubes required. Neglect the resistance offered by metallic tubes. (5)

Q8 Write short notes (any two) (5+5)

a) Regenerators and recuperator
b) Heat pipe
c) Differential thermal Expansion and thermal stresses