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M.TECH

HTPE204 / TFPE203

Second Semester Examination – 2013

HEAT EXCHANGER ANALYSIS AND DESIGN

Time: 3 Hours

Max marks: 70

Answer Question No.1 which is compulsory and any five from the rest.

The figures in the right hand margin indicate marks.

Q1. [2x10]

a) Water is flowing through a 12 mm tube filling 80% of its cross section. What is its hydraulic diameter?
b) What do you mean by correction factor for a cross flow heat exchanger?
c) Differentiate between regenerative and recuperative heat exchanger.
d) What is the purpose of using baffles in a heat exchanger?
e) What do you mean by mixed and unmixed flow as applied to cross flow heat exchanger?
f) When can the overall heat transfer coefficient be expressed as $U=(h_i^{-1}+h_o^{-1})$?
g) Draw the schematic of a two shell and four tube pass heat exchanger.
h) What is fouling factor and how do the temperature and the velocity affect it?
i) What will be the heat capacity rate of a fluid during boiling? Justify your answer.
j) When a heat exchanger is classified as compact heat exchanger? Give an example of a natural compact heat exchanger.

Q2. Cold water enters a counter flow heat exchanger at 10^O C at a rate of 8.0 kg/s, where it is heated by a hot water stream that enters the heat exchanger at 70^O C at a rate of 2.0 kg/s. C_P of water is 4.18 kJ/kg-K. Determine the maximum heat transfer rate and the outlet temperatures of the cold and the hot water streams for this limiting case. [10]

Q3. [2.5X4]

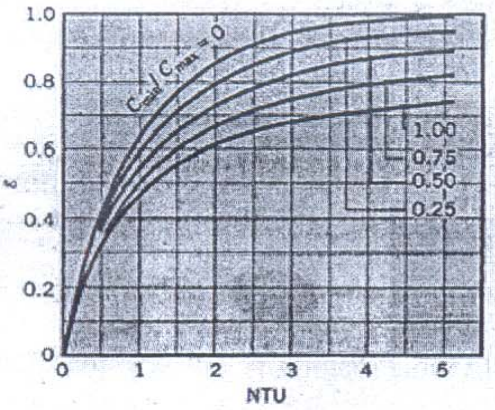
a) What are the common causes of fouling in a heat exchanger? How does fouling affects heat transfer and pressure drop?
b) Why is the maximum possible heat transfer rate for a heat exchanger is $C_{min}(T_{h,i}-T_{c,i})$ but not $C_{max}(T_{h,i}-T_{c,i})$?
c) How the TEMA charts are useful in design of multipass heat exchanger?
d) Explain a storage type heat exchanger.

Q4. Engine oil at 150^O C flowing through the shell side is used to heat 2.4 kg/s of water from 20^O C to 80^O C in a shell and tube heat exchanger. Water flows through eight tubes of 25 mm diameter. Each tube makes six passes through the shell. The exit oil temperature is 90^O C. Neglecting the tube wall resistance, find the oil flow rate and the length of the tubes. Oil side heat transfer coefficient is 400 W/m^2-K. C_P of oil is 2.34 kJ/kg-K. Water properties may be suitably assumed. Correction factor for this heat exchanger may be taken as 0.87. [10]

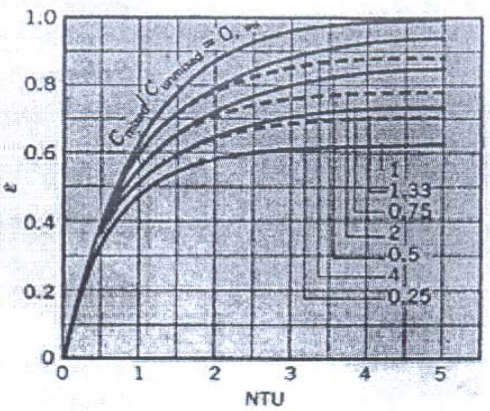
Q5. a) When one of the two fluids undergoes phase change, show that effectiveness values for both parallel flow and counter flow heat exchanger are equal and given by $\epsilon = 1-\exp(-NTU)$. [6]

b) Explain how the charts provided by Kays and London are useful in the design of heat exchangers? [4]

Q6. Water with a flow rate of 1 kg/s is heated from 35^{O} C to 125^{O} C by hot exhaust gas which enters a finned tube, cross flow heat exchanger at 300^{O} C and leaves at 100^{O} C. C_P of exhaust gas is 1 kJ/kg-K and U_h based on gas side surface area is 100 W/m^2-K. Determine the required gas side surface area using NTU method. Water properties may be suitably assumed. Refer to figure given below. [10]



Effectiveness of a single-pass, cross-flow heat exchanger with both fluids unmixed



Effectiveness of a single-pass, cross-flow heat exchanger with one fluid mixed and the other unmixed

Q7. The cooling water at a rate of 0.2 kg/s enters through the inner tube (D_i = 25 mm) at 30^{O} C of a counter flow concentric tube heat exchanger. The oil flows at a rate of 0.1 kg/s through the annulus (D_O= 45 mm) and enters at 100^{O} C. How long the tube be made if the the outlet temperature of the oil is 60^{O} C? Oil properties are C_P=2.13 kJ/kg-K, μ=3.25 x 10^{-2} N-s/m^2. k = 0.138 W/m.K. Water properties may be suitably assumed. Neglect the tube wall thickness. [10]

Q8. a) With a neat sketch discuss the purpose and principle of operation of a cooling tower. [5]

b) Discuss the factors to be considered while selecting the materials for a heat exchanger. [5]