PROBLEM

P.No.1. Water at the rate of 4 kg/s is heated from 38°C to 55°Cin a shell and tube heat exchanger. The water is to flow inside tubes of 2cm diameter with an average velocity of 35 cm/s. hot water available at95°C and the rate of 2 kg/s is used as the heating medium on the shell side. if the length of the tubes must not be more than 2m calculate the no. of tube passes , the no. tubes over pass and the length of the tubes for one shell pass, assuming U_o=1500 w/m^{2}k. Cp of water= 4186 J / kg K.

Solution:

Cold fluid

$\dot{m}_c$ = 4 kg/s

C_{pc} = 4186 J/kg K

T_{ca} = 38ºC ; T_{cb} = 55ºC

Hot fluid:

$\dot{m}_h$ = 2 kg/s

C_{ph} = 4186 J/kg K

T_{ha} = 95ºC

$Q = U\,A\,\overline{\Delta T_L}$

Enthalpy balance equation:

Q = $\dot{m}_c\, C_{pc}\left(T_{cb} - T_{ca}\right) = \dot{m}_h\, C_{ph}\left(T_{ha} - T_{hb}\right)$ = 284648 W

$4x\,4186(55-38) = 2x\,4186(95 - T_{hb})$

T_{hb} = 61 °C

$$\overline{\Delta T_L} = \frac{\Delta T_2 - \Delta T_1}{\ln\left(\frac{\Delta T_2}{\Delta T_1}\right)} = 30.72\ ^oC$$

ΔT_1 = $T_{ha} - T_{cb}$ = 40 °C

ΔT_2 = $T_{hb} - T_{ca}$ = 23 °C

Assumption ; Single pass shell and tube heat exchanger

$Q = U\,A\,\overline{\Delta T_L}$

A = 6.177 m^2 = NnπDoL

$\dot{m}_c = \rho\, u\, s$

$s = n\, (\pi D_i^2 / 4)$

$D_i = 0.02m$

$n = 36$

$A = Nn\pi DoL$

$N = 1$

$L = 2.73m$

Length is greater than 2m.So our assumption is not correct.

Assumption: 1-2 shell and tube heat exchanger

$Q = U\, A F_G\, \overline{\Delta T_L}$

Assumption: $F_G = 0.95$

$A = 6.5\ m^2$

$A = Nn\pi DoL$

Answer:

N = 2

n = 36

L = 1.43 m

Assignment

1. A counter flow shell and tube heat exchanger is used to heat water at the rate of 0.8 kg/s from 30°C to 80°C with hot oil entering at120°C and leaving at 85°C. The overall heat transfer coefficient is 125 $W/m^{2o}C$. Calculate the heat transfer area required.
2. Water at the rate of 68kg/min is heated from 35 to 75°C by oil having a specific heat of 1.9kJ/kgK. The fluids are used in counter flow double pipe heat exchanger and the oil enters the exchanger at 110°C and leaves at 75°C. The overall heat transfer coefficient 320W/m^{2}K.Calculate the heat transfer area.
3. An oil cooler for a large diesel engine is to cool engine oil from 60°C to 45°C, using sea water at an inlet temperature of 20°C with a temperature rise of 15°C. The design heat load is 140kW and the mean overall heat transfer coefficient based on outer surface area of the tubes is 70 $W/m^{2o}C$. Calculate the heat transfer surface area for single pass (a) counter flow and (b) parallel flow arrangement.
4. In a double pipe counter flow heat exchanger 10,000 kg/h of an oil having a specific heat of 2095 J/kgK is cooled from 80°C to 50°C by 8000kg/hr of water entering at 25°C.Determine the heat exchanger area for an overall heat transfer coefficient of 300W/m^{2}k.c_p of water=4180 J/kg K.
5. A counter flow tubular heat exchanger is used to cool engine oil(c_p=2130 J/kg K) from 160°C to 60°C with water, available at 25°C as the cooling medium. The flow rate of cooling water through the inner tube of 0.5m dia is 2kg/s while the flow rate of oil through the outer annulus O.D=0.7 is also 2kg /s. If the value of the overall heat transfer coefficient is 250W/m^{2}K, how long must the heat exchanger be to meet its cooling requirement?
6. Crude oil flows at a rate of 2000 Kg/hr thro' the inside pipe of a double pipe heat exchanger and is heated from 45°C to 100°C. The heat is supplied by a hot fluid initially at 225°C flowing thro' the annular space. If the temperature. of approach (min temperature. difference between the fluids) at the leaving end of hot fluid is 10°C, determine the heat transfer area and the required hot fluid flow rate for co- current and counter current flow patterns. Data : U_O = 454 $W/m^{2o}C$; Cp of crude oil= 2.34 kJ/kg K ; Cp of hot fluid= 2.51 kJ/kg K .
7. A heavy hydrocarbon oil is cooled in a counter current double pipe heat exchanger from 100°C to 75°C. The oil is flowing thro' inner tube at a rate of 1000 kg/hr. cold water enters the annulus at 15°C with a rate of 2000kg/ hr. Estimate the heat transfer area. Data:

overall heat transfer coefficient = 500 W/m^2K; specific heat of oil= 2.0 kJ/kg K; specific heat of water=4.00 kJ/kg K.

8. Saturated steam at 120°C is condensing on the outer tube surface of a single pass heat exchanger. The heat transfer coefficient is u_o= 1800 W/m^2K. Determine the surface area of a heat exchanger capable of heating 1000kg/h of water from 20°C to 90°C. Also calculate the rate of condensing of steam. λ_s= 2200 kJ/kg.
9. Water at the rate of 4080 kg/hr is heated from 35°C to 75°C by an oil having a specific heat of 1900 J/kg K. The exchanger is of a counter flow double pipe design. The oil enters at 110°C and leaves at 75°C. Determine the area of the heat exchanger necessary to handle this load if the overall heat transfer coefficient is 320 W/m^2K.
10. A pipe (k=59 w/mk) with an I.D. of 3.175 cm and wall thickness of 0.318 cm is externally heated by steam at a temperature. of 180°C . The water flows thro' the pipe with a velocity of 1.22 m/s. calculate the length of the pipe required to heat water from 30°C to 90°C assuming the heat transfer coefficient on the steam side to be 11.3 kW/m^2K. Data: ρ=982.3 kg/m^3 ; μ= 453 $\times 10^{-6}$ $N.s/m^2$; k=656$\times 10^{-3}$ w/mk; p_r=2.88
11. A shell and tube steam condenser is to be constructed of 2.5 cm O.D., 2.2cm I.D., single pass horizontal tubes with steam condensing at 54°Coutside the tubes. The cooling water enters each tube at 18°C with a flow rate of 0.7 kg/s per tube and leaves at 36°C . The heat transfer coefficient for the condensation of the steam is 8000 $W/m^{2o}C$. Calculate the tube length and the condensation rate per tube. The properties of water at 27°C are, C_p=4180 J/kg K; μ=0.86$\times 10^{-3}$ kg/m.s; p_r= 5.9; k=0.61 W/mK; λ_s=2372.400 kJ/kg.
12. Hot engine oil available at 150°C flowing through the shell side is used to heat 2.4kg/s of water from 20°C to 80°C in a shell and tube heat exchanger. Water flows through eight tubes of 25mm diameter. Each tube makes six passes through the shell. The exit oil temperature is 90°C. Neglecting the tube wall resistance, find the oil flow rate and length of the tubes. Take the oil side heat transfer coefficient as 400 W/m^2K.For engine oil at 140°C; Cp = 2.34 kJ/kg K. For water at 50°C; Cp = 4.181kJ/kg K; μ = 548 x 10^{-6} Ns/m^2; k = 0.643 W/mK and Pr = 3.56
13. The condenser of a large steam power plant is a shell and tube heat exchanger having a single shell and 30000 tubes, with each tube making two passes. The tubes are thin walled with 25mm diameter and steam condenses on the outside of the tubes with ho= 11 kW/m^2K. The cooling water flowing through the tubes is 30000kg/s and the heat transfer rate is 2 x 10^9W.Water enters at 20°C while steam condenses at 50°C. Find the length of

the tubes in one pass. Properties of water at bulk mean temperature are Cp = 4.18 kJ/kg K; μ = 855 x 10^{-6} Ns/m^2; k = 0.613 W/mK and Pr = 5.83

14. Warm water is required at rate of 500 kg/hr for washing a filter cake, and it is decided to use a 25 mm steam heated tube for the purpose. The wall is maintained at 130°C by condensing steam on the outside surface . Calculate the length of the tube required to heat water from 30°C to 50°C at the required rate. Use the Dittus- Boelter eqn to calculate the heat transfer coefficient. The I.D. of the tube is 21.2mm. Data; μ=6.82×10^{-4} kg/ms; κ=0.63 W/m°C, c_p= 4.174 k J/kg K. Neglect the resistance of the tube wall.
15. In a food processing plant, water is to be cooled from 18°C to 6.5°C by using brine solution entering at the inlet temperature of -1.1°C and leaving at 2.9°C. What area is required when using a shell and tube heat exchanger with the water making one shell pass and the brine making two tube passes. Assume an average overall heat transfer coefficient of 850 W/m^2K and a design heat load of 6000W.
16. Water at the rate of 4 kg/s is heated from 38°C to 55°C in a shell and tube heat exchanger. The water is to flow inside tubes of 2cm diameter with an average velocity of 35 cm/s. hot water available at95°C and the rate of 2 kg/s is used as the heating medium on the shell side. If the length of the tubes must not be more than 2m, calculate the no. of tube passes , the no. tubes over pass and the length of the tubes for one shell pass, assuming U_o=1500 W/m^2K. Cp of water= 4186 J/kg K.
17. Determine the area of one shell pass and 2 tube pass heat exchanger to heat water with a mass flow rate of 68 kg/min. from 35°C to 75°C by oil having a specific heat of 1.9 k J/kg K. The oil flowing thro' the tubes, enters the exchanger at 110°C and leaves at 75°C. The overall heat transfer coefficient is 320 W/m^2K.
