Assignment III [2021]

ME 307: Heat Transfer Equipment Design

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1. A plate and frame heat exchanger is used to exchange heat in a water-to-water flow system. Hot water enters the exchanger at 32.2°C with a flow rate of 0.0126 m^3/s. Cold water also at 0.0126 m^3/s enters the exchanger at 12.8°C. The exchanger contains 27 plates. The plate spacing is 5.08 mm, the plate material is stainless steel, the plate thickness is 1.016 mm, the plate width is 381 mm, the plate height is 0.914 m. Determine the outlet temperatures of the both the fluids.

2. Water enters a cross-flow heat exchanger at a temperature of 85°C and a flow rate of 2.5 kg/s. Air enters the exchanger at 20°C, leaves at 40°C, and has a flow rate of 12 kg/s. Which type of cross-flow heat exchanger will have the greater effectiveness - mixed-unmixed or unmixed-unmixed? Does it make a difference which fluid is mixed?

3. Design a shell-and-tube heat exchanger to be used as a engine oil cooler. 120 kg/s of oil enters the shell side of the heat exchanger at 102°C and leaves at 65°C. The coolant to be used is city water entering the tube side at 21°C with a flow rate of 65 kg/s. Shell-side pressure drop is limited to 150 kPa.

4. Hot water at 0.0063 m^3/s, 82.2°C, enters a plate and frame heat exchanger and is cooled to 57.2°C. Cold water enters the heat exchanger at 0.00756 m^3/s, 37.8°C. The plates are made of stainless steel with a heat transfer area of 0.316 m^2 per plate. The plate spacing is 5.08 mm,the plate thickness is 1.016 mm, the plate width is 381 mm. Determine the number of plates for the exchanger to work.

5. Steam at a saturation temperature of 100°C is condensing in a bundle of 320 tubes within a 0.56 m wide duct. The tubes are arranged in a square, in-line pitch (p = 35.0 mm). The bundle is made of up to 20 rows of tubes with 3 cm OD and with 16 tubes in each row. The tube wall temperature in each row is kept constant at 93°C. The steam flows downward in the bundle, and at the 6th row of tubes, the local mass flow rate of vapour is 14.0 kg/s. Find the average heat transfer coefficient.

6. DPHX Rating: Oil is to be heated from 30°C using hot water at 100°C. Oil flow rate is 0.06 kg/s in the annulus, while water flow rate is 0.5 kg/s.The heat exchanger is made of 2 x 1 1/4 std type M copper tubing that is 5.0 m long. Use appropriate fouling factors, rate the DPHX.

7. DPHX Sizing: Oil is to be heated to 45 °C from 30°C using hot water at 100°C. Oil flow rate is 0.05 kg/s in the annulus, while water flow rate is 0.5 kg/s.The heat exchanger is made of 2 x 1 1/4 std type M copper tubing. Use appropriate fouling factors, size the DPHX.

8. STHX Rating: 20.0 kg/s water at 50°C is to be cooled using 20.0 kg/s water available at 25 °C. $N_t = 200$, $N_p = 2$, $L = 5.0$, $N_b = 15$, $B = 304.8$ mm, $D_s = 438.2$ mm, $ID_t = 16.55$ mm, $OD_t = 19.07$ mm. Assume 25.4 mm triangular pitch.

9. PFHX Rating: 0.975 kg/s water at 25°C is to be cooled using 1.0 kg/s water available at 7°C. If b = 457 mm, L = 914 mm, s = 5.08 mm, t = 1.016 mm, k = 14.3 W/mK, Ns = 11, fouling coefficients for both fluids = 3.52 x 10^{-6}, rate the heat-exchanger.

10. Condenser Sizing: Saturated water at 75°C with a quality of $x_i = 0.95$ and a mass flow rate, $\dot{m}_h = 10$ kg/s is to be cooled to 30°C with a water flow of $\dot{m}_c = 40$ kg/s at 20°C. If for liquid water, $h_w = 8000$ W/m^{2}K, and for condensing vapour, $h_v = 24000$ W/m^{2}K, estimate the heat transfer surface area.