Problem Sheet on Heat Exchanger

1. A feed water heater uses a shell and tube exchanger with condensing steam in one shell pass at 120°C. Water enters the tubes at 30°C and makes four passes to produce an overall U value of 2000 W/m2 K. Calculate the area of the exchanger for 2.5 kg/s mass flow of the water, with a water exit temperature of 100°C.
2. A reaction mixture having a mean heat capacity of 2.85 kJ/(kg K) is flowing at a rate of 7260 kg/h and is to be cooled from 377.6K to 344.3K. Cooling water (C_p = 4179 kJ/kg.K) at 288.8 K is available and the flow rate is 4536 kg/h. The overall heat transfer coefficient based on the outer area is 653 W/(m^2 K). Determine the effectiveness NTU of the heat exchanger if it is operated in (a) counterflow mode, and (b) parallel flow mode.
3. Oil flowing at the rate of 7258 kg/h with a mean heat capacity of 2.01 kJ/(kg K) is cooled from 394.3 K to 338.9 K in a counterflow heat exchanger by water entering at 294.3K and leaving at 305.4 K. Calculate the flow rate of the water and the overall heat transfer coefficient based on the inner area U_i if the inner area is 5.11 m^2.
4. The liquid metal bismuth enters a tube having an inside diameter of 35 mm at 425^{o}C and is heated to 430^{o}C in the tube. The flow rate of the bismuth is 2.00 kg/s. The tube wall is maintained at a temperature of 25^{o}C above the liquid bulk temperature. Calculate the tube length required. The physical propoerties of bismuth are as follows: k=15.6 W/(m K), C_p=149 J/(kg K), viscosity = 1.34 x 10^{-3} Pa s.
5. After a long time in service, a counterflow heat exchanger for cooling of turbine lube oil in a power plant is checked to ascertain if its performance has deteriorated due to fouling. In the test SAE 50 oil flowing at 2.0 kg/s is cooled from 420 K to 310 K by a water supply of 1.0 kg/s at 300 K. If the overall heat transfer surface is 3.33. m^2 and the design value of overall heat transfer coefficient is 930 W/m^2, find the percentage degradation of the overall heat transfer coefficient from design value. C_p for SAE oil is 2330 J/kgK nd that fr water is 4187 J/kgK.
6. You are asked to design a double-pipe counterflow heat exchanger for an application that will continuously heat a process stream (C_p=4.85kJ/kg K, mass flow rate=0.584 kg/s) from 25^{o}C to 95^{o}C. The heat-transfer fluid will be Thermatic® (C_p=12.8 kJ/kg K), which will be fed at 125^{o}C. The mass flow rate of the Thermatic® is not specified and must be chosen in the design process. The viscosities of the process fluid and of the Thermatic® may be assumed to be constant (not a function of temperature). The overall heat-transfer coefficient U for the heat exchanger is 100 W/m^2K. Determine the heat transfer surface needed.
7. Engine oil (C_p=2100 J/kg.K) is to be heated from 20^{o}C to 60^{o}C by steam in a heat exchanger. The oil is passed through a 2 cm diameter copper pipe at 0.3 kg/s rate, while steam at 130^o C (h_{fg} = 2174 kJ/kg.K) is condensed as it passes through the annular space between the outer and the inner tubes. The outside walls of the outer tubes are insulated such that there is no heat loss. If the overall heat transfer coefficient (based on the inner tube) is 650 W/m^2.K, determine the rate of heat transfer and the length of tube required to achieve this. Also calculate the effectiveness of the heat exchanger if it operates (i) in parallel flow and (ii) in counterflow mode. Neglect the thickness of the inner tube, and assume steady state.
8. Water flowing at a rate of 0.667 kg/s enters a countercurrent, double-pipe heat exchanger at 308K and is heated by an oil stream entering at 383K at a rate of 2.85 kg/s (c_p=1.89 kJ/(kg K). The overall heat transfer coefficient of the heat exchanger is 300 W/(m^2 K) and the heat transfer area in the exchanger is 15.0 m^2. Calculate the heat-transfer rate and the exit water temperature.
9. Steam at 1.00 atm pressure (absolute) and 100^{o}C is condensing on a bank of 5 vertical tubes each 0.305 m high and having an outer diameter of 1.00 in. The tubes are

arranged in a bundle spaced far enough apart so that they do not interfere with each other. The surface temperature of the tubes is 97.78^oC. Calculate the average heat-transfer coefficient and the total mass flow rate of condenstate (kg/h).

10. A 1-2 shell-and-tube heat exchanger with one shell pass and two tube passes is used to heat a cold fluid from 37.8^oC to 121.1^oC by using a hot fluid entering at 315.6^oC. The temperature of the hot fluid leaving the exchanger is measured to be 148.9^oC. Calculate the log-mean temperature difference in the exchanger and the mean temperature difference in the exchanger. Comment on these answers - why are they different? Are they different in the way you expected?
11. Oil flowing at a rate of 5.04 kg/s (mean C_p=2.09 kJ/(kg K)) is cooled in a 1-2 shell-and-tube heat exchanger from 366.5K to 344.3K by water flowing at 2.02 kg/s entering at 283.2 K. The overall heat-transfer coefficient based on the outer area is 340. W/(m^2 K). Calculate the area required.
12. Hot oil at a flow rate of 3.00 kg/s (heat capacity C_p=1.92 kJ/(kg K)) enters an existing counterflow exchanger at 400.K and is cooled by water entering at 325 K (under pressure) and flowing at a rate of 0.70 kg/s. The overall heat-transfer coefficient is 350. W/(m^2 K) and the heat-transfer area is 12.9 m^2. Calculate the heat-transfer rate and the exit oil temperature.
13. A countercurrent, double-pipe heat exchanger (inner heat transfer area = 42.6 m^2, overall heat-transfer coefficient based on the area given = 340. W/(m^2 K)) was designed to cool a vegetable oil (mean heat capacity = 5.62 kJ/(kg K), flow rate = 5.3 kg/s) from 120.^oC to 85^oC using city water as the cooling fluid. The city water is supplied at a temperature of 18^oC.
    a. What is the outlet temperature of the city water for the conditions given?
    b. What will be the area of the heat exchanger if the same performance is to be achieved by a parallel flow heat exchanger?