ME 1065 – HW #2
Due 9/17/08

1. A heat exchanger is composed of rows of brass tubes. Steam flows inside the tubes, and air flows over the outside of the tubes in a cross-flow configuration. The brass tubes have an inner diameter of 1.8 cm, and an outer diameter of 2.1 cm. The convection heat transfer coefficients for the air and the steam are 70 W/m^2K and 210 W/m^2K, respectively.
   a. Calculate the overall heat transfer coefficient for the heat exchanger based on the inner tube area.
   b. Calculate the overall heat transfer coefficient for the heat exchanger based on the outer tube area.
   c. If a fouling factor of 0.00018 m^2K/W develops on the inside of the tube, what is the overall heat transfer coefficient based on the inner tube area?

2. Water is heated by hot air in a heat exchanger. The flow rate of the water is 12 kg/s and the flow rate of the air is 2 kg/s. The water enters at 40˚C, and the air at 460˚C. The surface area of heat exchange is 14 m^2, and the overall heat transfer coefficient is 275 W/m^2K. For both a parallel-flow and a cross-flow (both fluids unmixed) type of heat exchanger, determine the:
   a. effectiveness of the heat exchanger,
   b. heat transfer rate, and
   c. outlet temperatures of the water and the air.

3. In a counterflow heat exchanger, 10,000 lb_m/hr of water enters at 60˚F, and cools 20,000 lb_m/hr of an oil (c_p = 0.5 Btu/lb_m·˚R) from 200˚F to 150˚F. If the overall heat transfer coefficient is 50 Btu/hr·ft^2·˚F, determine the required surface area.

4. Oil is to be heated in a double pipe counterflow heat exchanger from 90˚F to 100˚F. The oil flow rate is 400 lb_m/hr. Water at 150˚F is available at 5000 lb_m/hr. The heat exchanger is made up of 1¼-std type and 2-std type M copper tubing that is 15 feet long. The oil is in the annulus, and the properties of this oil at 95˚F are ρ = 54.8 lb_m/ft^3, c_p = 0.464 Btu/lb_m·˚R, υ = 4.27 x 10^{-3} ft^2/s, k = 0.0832 Btu/hr·ft·˚R, Pr = 4699, and α = 0.00327 ft^2/hr. Using the ε–NTU method, completely analyze the heat exchanger, determining:
   a. the Reynolds numbers of the water and the oil,
   b. the Nusselt numbers of the water and the oil,
   c. the overall heat transfer coefficient (with respect to the outer surface of the inner tube), and
   d. the heat transfer rate.