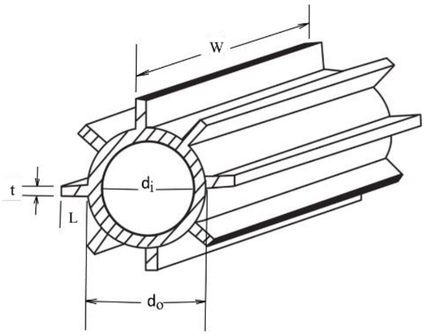
King Abdulaziz University
Mechanical Engineering Department

MEP460
Heat Exchanger Design
Spring 2021 HW04 Answers
HX methods



1-A steel tube (k=**60** W/mK) of inner and outer diameters D_i= 20 mm and D_o= 26 mm, respectively, is used to transfer heat from hot gases flowing over the tube (h_h=200 W/m^{2}K) to cold water flowing through the tube (h_c=8000 W/m^{2}K). What is the cold-side overall heat transfer coefficient U_c=? To enhance heat transfer,16 straight fins of rectangular profile are installed longitudinally along the outer surface of the tube. The fins are equally spaced around the circumference of the tube, each having a thickness of 2 mm and a length L=**20** mm. Assume the pipe length to be 1m. What is the corresponding overall heat transfer coefficient U_c? **[11.4]** **{**Ans. η_o=0.73, $U_{no,fins}$=249.1 W/m^2.K, $U_{w,fins}$=1306 W/m^2.K}

2-The hot and cold inlet temperatures to a concentric tube heat exchanger are $T_{h,i}$*=200ºC,* $T_{c,i}$=100ºC, respectively. The outlet temperatures are $T_{h,o}$=110ºC and $T_{c,o}$=**130**ºC. Is the heat exchanger operating in a parallel flow or in a counterflow configuration? What is the heat exchanger effectiveness? What is the NTU? Phase change does not occur in either fluid. **[11.16]** {Ans. ε=0.3, NTU=0.377}

3-A counterflow, concentric tube heat exchanger is designed to heat water from 20 to 80ºC using hot oil, which is supplied to the annulus at 160ºC and discharged at 140ºC. The thin-walled inner tube has a diameter of D_i=20 mm, and the overall heat transfer coefficient is **450** W/m^{2}K. The design condition calls for a total heat transfer rate of 3000 W.

(a) What is the length of the heat exchanger?

(b) After 3 years of operation, performance is degraded by fouling on the water side of the exchanger, and the water outlet temperature is only 65ºC for the same fluid flow rates and inlet temperatures. What are the corresponding values of the heat transfer rate, the outlet temperature of the oil, the overall heat transfer coefficient, and the water-side fouling factor $R''_{f,c}$? **[11.18]** {Ans. L=1.08 m, U_{3y}=304.6 W/m^{2}K, T_{ho}=145 ºC, $R''_{fi} = 0.0010\ m^2.K/W$ }

4-Saturated process steam at 1 atm is condensed in a shell-and-tube heat exchanger (one shell, two tube passes). Cooling water enters the tubes at 15ºC with an average velocity of **3.0** m/s. The tubes are thin walled and made of copper with a diameter of 14 mm and length of 0.5 m. The convective heat transfer coefficient for condensation on the outer surface of the tubes is 21,800 W/m^2 K.

(a) Find the number of tubes/pass required to condense **2.5** kg/s of steam.

(b) Find the outlet water temperature.

(c) Find the maximum possible condensation rate that could be achieved with this heat exchanger using the same water flow rate and inlet temperature **[11.56]** {Ans. N_{tbp}=223 tubes, N_t=446 tubes, T_{co}=28.2 ºC, $m_{cond,max}$=16.14 kg/s }

5-A shell-and-tube heat exchanger with one shell pass and 20 tube passes uses hot water on the tube side to heat oil on the shell side. The single copper tube has inner and outer diameters of 20 and 24 mm and a length per pass of 3 m. The water enters at 87ºC and **0.3** kg/s and leaves at 27ºC. Inlet and outlet temperatures of the oil are 7 and 37ºC. What is the average convection coefficient for the tube outer surface? **[11.58]** {Ans. ε=0.75, h_i=4907 W/m^{2}K, h_o=1246 W/m^{2}K }

6-A cross-flow heat exchanger consists of a bundle of 32 tubes in a 0.6-m^2 duct. Hot water at 150º C and a mean velocity of 0.5 m/s enters the tubes having inner and outer diameters of 10.2 and 12.5 mm. Atmospheric air at 10º C enters the exchanger with a volumetric flow rate of **1.2** m^3/s. The convection heat transfer coefficient on the tube outer surfaces is **350** W/m^2 K. Assume the length of the tubes is 1 m. Estimate the fluid outlet temperatures **[11.66]** {Ans. Re_i=25149, h_i=5280 W/m^{2}K, U_o=323.7 W/m^{2}K, ε=0.235, T_{co}=32.6 ºC}