Part A

Problem 11.42 of Incropera & DeWitt
Problem 11.41 of Incropera & DeWitt

Part B

Problem 11.14 of Incropera & DeWitt
Problem 11.32 of Incropera & DeWitt

Part C

A one-shell-pass, two-tube-pass heat exchanger is being designed to cool vegetable oil from 150°C to 60°C. The oil flows through stainless steel tubes with an O.D. of 15mm and a tube wall thickness of 1mm. Cooling water, which enters at 20°C, flows on the outside of the tubes. It is estimated that the heat transfer coefficient on the water side will be 1000W/m²-K and that the coefficient on the oil side will be 300W/m²-K. The oil flow rate will be equal to 1kg/s and the water flow rate will be 0.5kg/s.

a. What is the required exchanger area (based on tube O.D.)?

b. The exchanger is put into service and operates satisfactorily, but its performance gradually declines. At the end of one year, the oil outlet temperature is 80°C. It is speculated that the oil-side is fouled. How thick would a layer of stagnant goo have to be to explain the result? Is this plausible?

Data

Oil
k = 0.139 W/m·K
ρ = 850 kg/m³
\( c_p = 2120 \text{ J/kg·K} \)

Water
k = 0.670 W/m·K
ρ = 975 kg/m³
\( c_p = 4190 \text{ J/kg·K} \)

(continued)
**Goo**

\[ k = 0.139 \text{ W/m} \cdot \text{K} \]

**Stainless Steel**

\[ k = 15 \text{ W/m} \cdot \text{K} \]
\[ \rho = 8000 \text{ kg/m}^3 \]
\[ c_p = 480 \text{ J/kg} \cdot \text{K} \]

**Part D**

A suspension of finely divided camphene \((C_{10}H_{16})\) in water is to be heated from 100°F to 130°F by hot water, available at a temperature of 140°F. The suspension contains 20 weight percent camphene and 80 weight percent water, and its flow rate is 5,000 lb/hr. It is proposed to use a concentric pipe heat exchanger, with the suspension flowing inside a 2-inch O.D. 16 BWG copper tube and the hot water flowing in the annulus between the copper tube and a 2-1/2 inch standard steel pipe. The overall heat transfer coefficient (based on outside tube area) will be 200 Btu/hr ft\(^2\)°F.

(a) How long must the exchanger be if the hot water flow rate is 9,000 lb/hr?

(b) How long must the exchanger be if the hot water flow rate is 7,000 lb/hr?

**Data and Notes:**

1. The solubility of camphene (solid or liquid) in water, and of the water in camphene, is assumed to be negligible.

2. The exchanger is to be well insulated on the outside.

**Properties of Camphene:**

- Specific heat of solid = 0.38 Btu/(lb) (°F)
- Specific heat of liquid = 0.40 Btu/(lb) (°F)
- Melting point = 122°F
- Latent heat of fusion = 103 Btu/lb

Take the heat capacity of water to be 1.0 Btu/lb. °F.