10.302
Fall 2004
Discussion Problem for Recitation on
Tuesday, November 9, 2004

A one-shell-pass, two-tube-pass heat exchanger is being designed to cool vegetable oil from 150ºC to 60ºC. 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 20ºC, flows on the outside of the tubes. It is estimated that the heat transfer coefficient on the water side will be $1000 W/m^2\cdot K$ and that the coefficient on the oil side will be $300 W/ m^2\cdot K$. The water flow rate and the oil flow rate will each be equal to 1kg/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 80ºC. 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?

c. If the exchanger were infinitely large, what would be the required water flow rate to cool 1 kg/s of oil from 150ºC to 60ºC?

<u>Data</u>

<u>Oil</u>

$k = 0.139$ W/m·K
$\rho = 850$ kg/m^3
$c_p = 2120$ J/kg·K

<u>Water</u>

$k = 0.670$ W/m·K
$\rho = 975$ kg/m^3
$c_p = 4190$ J/kg·K

<u>Goo</u>

$k = 0.139$ W/m·K

<u>Stainless Steel</u>

$k = 15$ W/m·K
$\rho = 8000$ kg/m^3
$c_p = 480$ J/kg·K