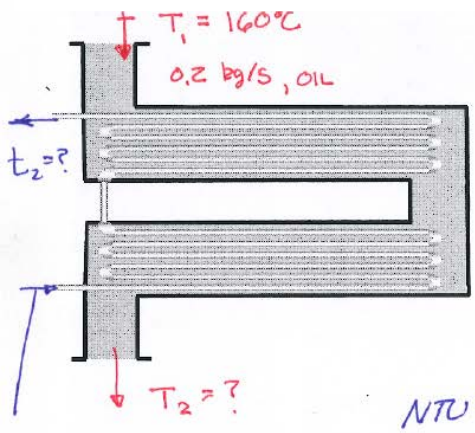
Example

0.2 kg/s of hot oil (c_p = 2200 J/kg-°C) is to be cooled by water (c_p = 4180 J/kg-°C) in a 2-12 shell and tube HXR. The water flows through thin-walled tubes with a diameter of 1.8 cm at a rate of 0.1 kg/s. The length of each tube pass is 3 m and the overall heat transfer coefficient is 340 W/m²-°C. (Tube side or shell side? Does it matter?) The inlet temperatures of the oil and water are 160°C and 18°C, respectively.

(a) Find the rate of heat transfer in the exchanger and
(b) the exit temperatures of both fluids.



a) $\dot{Q} = \varepsilon \dot{Q}_{MAX}$

$= \varepsilon (\dot{m}c_p)_{MIN} (T_1 - t_1)$

$(\dot{m}C)_{WATER} = (0.2)(2200) = 440$ W/C°

$(\dot{m}C)_{OIL} = (0.1)(4180) = 418$ W/C°

$(\dot{m}C)_{MIN}$

$\varepsilon = f(NTU, c)$

$NTU = \frac{UA}{(\dot{m}C)_{MIN}}$ → ?

$A = N \cdot \pi DL$

$= (12)(\pi)(0.018)(3) = 2.04\ m^2$

$= \frac{\left(340 \frac{W}{m^2 C^\circ}\right)(2.04\ m^2)}{\left(418 \frac{W}{C^\circ}\right)} = 1.656$

$c = \frac{418}{440} = 0.95$

FIGURE

$\varepsilon \approx 0.61$

$\dot{Q} = (0.61)(418)(160 - 18) = \boxed{36{,}200\ W}$

b) OIL:

$\dot{Q} = (\dot{m}C)_{OIL}(T_1 - T_2)$

$T_2 = T_1 - \frac{\dot{Q}}{(\dot{m}C)_{OIL}}$

$= \ldots = \boxed{77.7°C}$

WATER:

$\dot{Q} = (\dot{m}C)_{WAT}(t_2 - t_1)$

$t_2 = t_1 + \frac{\dot{Q}}{(\dot{m}C)_{WAT}}$

$= \ldots = \boxed{105°C}$