

Calculations:

Heat removed from 1 can

$$Q_1 = m c_p (T_i - T_f) \Rightarrow (0.355)(4184)(29.44 - 4.44) = 37133 \text{ J} \Rightarrow 37.1 \text{ kJ}$$

Heat removed from 6 cans

$$Q_6 = 6 Q_1 \Rightarrow 6(37.1) = 222.6 \text{ kJ}$$

Req avg heat removal rate

$$\dot{Q}_{\text{req}} = \frac{Q_6}{t_{\text{max}}} \Rightarrow \frac{222.6}{300} = 742 \text{ W}$$

Can Surface area

$$A = \pi D L + 2 \left(\frac{\pi D^2}{4} \right) \Rightarrow \pi(0.06985)(0.12065) + 2 \left[\frac{\pi(0.06985)^2}{4} \right] = 0.03414 \text{ m}^2$$

Required overall heat transfer coeff

$$\frac{T_f - T_{\infty}}{T_i - T_{\infty}} = \frac{4.44 - (-7.78)}{29.44 - (-7.78)} = 0.328$$

$$\frac{T - T_{\infty}}{T_i - T_{\infty}} = \exp\left(-\frac{UA}{m c_p}\right)$$

$$U_{\text{req}} = -\frac{m c_p}{A} \ln\left(\frac{T_f - T_{\infty}}{T_i - T_{\infty}}\right) \Rightarrow -\frac{(0.355)(4184)}{(0.03414)(300)} \ln(0.328) = 161 \text{ W/m}^2 \cdot \text{K}$$

$$U_{\text{design}} = 180 \text{ W/m}^2 \cdot \text{K}$$

Req external convection coeff

$$\frac{1}{U} = \frac{1}{h_i} + \frac{\delta_{Al}}{k_{Al}} + \frac{1}{h_o}$$

Aluminum wall is thin

$$\frac{1}{U} = \frac{1}{h_i} + \frac{1}{h_o} \Rightarrow \frac{1}{180} = \frac{1}{210} + \frac{1}{h_o} \Rightarrow h_o = 1260 \text{ W/m}^2 \cdot \text{K}$$

Required Coolant Velocity

$$k = 0.552 \text{ W/(m} \cdot \text{K)}$$

$$\nu = 1.788 \times 10^{-6} \text{ m}^2/\text{s}$$

$$Pr = 13.6$$

$$Nu_D = \frac{h_o D}{k} \Rightarrow \frac{(1260)(0.06985)}{0.552} = 159$$