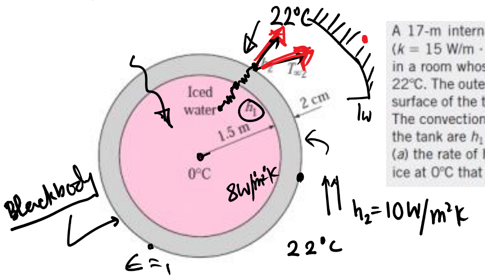
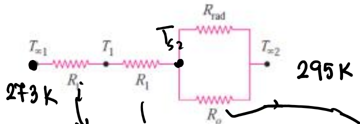
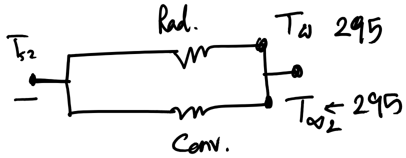
Tuesday, March 16, 2021 2:09 PM



A 17-m internal diameter spherical tank made of 2-cm-thick stainless steel (k = 15 W/m · °C) is used to store iced water at $T_{\infty 1}$ = 0°C. The tank is located in a room whose temperature is $T_{\infty 2}$ = 22°C. The walls of the room are also at 22°C. The outer surface of the tank is black and heat transfer between the outer surface of the tank and the surroundings is by natural convection and radiation. The convection heat transfer coefficients at the inner and the outer surfaces of the tank are h_1 = 80 W/m² · °C and h_2 = 10 W/m² · °C, respectively. Determine (*a*) the rate of heat transfer to the iced water in the tank and (*b*) the amount of ice at 0°C that melts during a 24-h period.



$$\frac{1}{h_1 A_i} \qquad \frac{1}{4\pi k}\left[\frac{1}{a} - \frac{1}{b}\right] \qquad \frac{1}{h_o A_o}$$



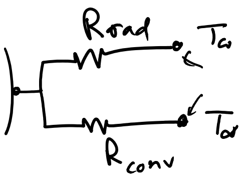
T_{s2} —/\/\/— T_w

$$\dot{Q}_{rad} = \sigma \epsilon 4\pi b^2 (T_{s2}^4 - T_w^4)$$

$$= \sigma \epsilon 4\pi b^2 (T_s - T_w)(T_s^2 + T_w^2)(T_s + T_w)$$

$$= \frac{T_s - T_w}{\left[\frac{1}{\sigma \epsilon 4\pi b^2} \times \frac{1}{(T_s^2+T_w^2)(T_s+T_w)}\right]}$$

R_{rad}



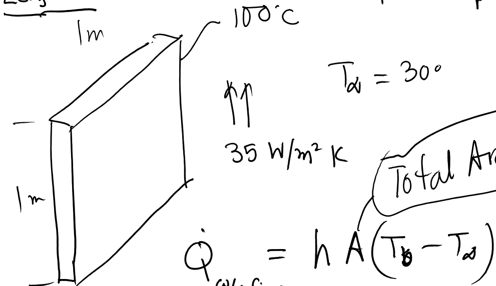
$$R_{total} = R_i + R_1 + R_o \| R_{rad}$$

$=$

—/\/\/— $\frac{1}{hA}$

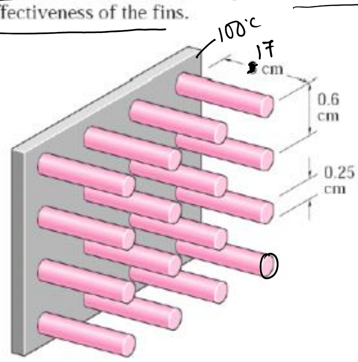
① Assume insulated fin tip → ③ Prescribed h at the fin tip ||
② Long fin

18 A hot surface at 100°C is to be cooled by attaching 17-cm-long, 0.25-cm-diameter aluminum pin fins (k = 237 W/m · °C) to it, with a center-to-center distance of 0.6 cm. The temperature of the surrounding medium is 30°C, and the heat transfer coefficient on the surfaces is 35 W/m² · °C. Determine the rate of heat transfer from the surface for a 1-m × 1-m section of the plate. Also determine the overall effectiveness of the fins.

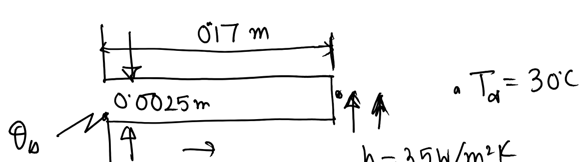


Total Area of the plate

$$\dot{Q}_{w/o\ fins} = h A (T_b - T_\infty)\ W$$
$$= 35 \times 1 \times 70$$
$$\dot{Q}_{w/o\ fin} = 2450\ W$$



$$m = \sqrt{\frac{hP}{kA_c}}$$



$$m = \sqrt{\frac{hP}{kA_c}} = \sqrt{\frac{h \times 2\pi r}{k \pi r^2}}$$

$$\dot{Q}_{f,convective} = -kA_c \left.\frac{dT}{dx}\right|_{x=0} = \sqrt{hPkA_c}\ \theta_b \frac{\{\sinh mL + (h/mk)\cosh mL\}}{\{\cosh mL + (h/mk)\sinh mL\}}\ W$$

$h = 35\ \mathrm{W/m^2K}$

$$\dot{Q}_{f,convective} = -kA_c \left.\frac{dT}{dx}\right|_{x=0} = \sqrt{hPkA_c}\,\theta_b\,\frac{\{\sinh mL + (h/mk)\cosh mL\}}{\{\cosh mL + (h/mk)\sinh mL\}}$$

$\dot{Q}_f$

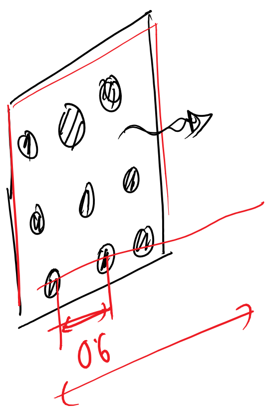
$$m = \sqrt{\frac{hP}{kA_c}} = \sqrt{\frac{h \times 2\pi r}{k\,\pi r^2}} = \sqrt{\frac{2h}{kr}} = \sqrt{\frac{4h}{kd}} = \sqrt{\frac{4\times 35}{237\times 0.0025}} = 15.37$$

$L = 0.17$

$mL < 5$ → $mL = 15.37 \times 0.17 = 2.61$

Effective ness of a single fin $\Big\}$ $\epsilon_f = \dfrac{\dot{Q}_f}{hA_c(T_b - T_\infty)} \Rightarrow \dot{Q}_f = \epsilon \times hA_c\Delta T$

(A_c: 0.0025)



$$\dot{Q}_{surface} = N \times \dot{Q}_{f,conv.} + (A - NA_c)\,h\,\Delta T$$

$$= N \cdot h\Delta T A_c \epsilon_f + (A - NA_c)\,h\Delta T$$

H.T. through the fins; H.T. through the unfinned area

$$N = \left(\frac{1}{0.006}\right)^2$$

$$= \{NA_c\epsilon_f + A - NA_c\}\,h\Delta T$$

$$= [NA_c(\epsilon_f - 1) + A]\,h\Delta T$$

$$\epsilon_{surface} = \frac{\dot{Q}_{surface}}{\dot{Q}_{w/o\ fin}} = \frac{[NA_c(\epsilon_f - 1) + A]\,h\Delta T}{A\,h\Delta T} = \left\{\frac{NA_c}{A}(\epsilon_f - 1) + 1\right\}$$