(16-29) given: $d = 20cm$ $t = 0.2cm$ $T_{in} = 0°C$

$T_{out} = 5°C$ $h_f = 333.7 \frac{kJ}{kg}$

find: $\dot{Q}_{out}$, $\dot{m}_{ice}$

Solution: $\dot{Q} = kA_{out}\left(\frac{T_{out} - T_{in}}{L}\right)$

$L = t = 0.002m$

$d = 0.2m$

$A_{out} = 4 \cdot \pi (0.1)^2$

$A_{out} = 0.126 m^2$

$k = 80.2 \frac{W}{mk}$

$\dot{Q} = 80.2 \cdot 0.126 \cdot \left(\frac{5-0}{0.002}\right)$

$\dot{Q} = 25.2kW$

$\dot{m}_{ice} = \frac{\dot{Q}}{h_f} = \frac{25.2}{333.7}$

$\dot{m}_{ice} = 0.0755 \frac{kg}{s}$

16-65 given: $T_\infty = 18^\circ C$ $A = 1.7 m^2$ $T_{skin} = 32^\circ C$

$\varepsilon =$ $h = 5 \frac{W}{m^2 K}$

find: $\dot{Q}_{out}$

solution:

$$\dot{Q}_{out} = \dot{Q}_{conv} + \dot{Q}_{emi}$$

$$\dot{Q}_{conv} = hA(T_{skin} - T_\infty) = 5 \cdot 1.7(32-18) = 119\ W$$

$$\dot{Q}_{emi} = \varepsilon \sigma A (T_{skin}^4 - T_\infty^4) = 0.9 \cdot 5.67 \times 10^{-8} (305.15)^4 - (291.15)^4) = 128.8\ W$$

$$\dot{Q}_{out} = 119 + 128.8$$

$$\boxed{\dot{Q}_{out} = 247.8\ W}$$

16-66 given: $T_1 = 27^\circ C$ $T_2 = 44^\circ C$ $t = 25cm$

$T_\infty = 40^\circ C$ $h = 8 \frac{W}{m^2 K}$ $\dot{q}_{sun} = 150 \frac{W}{m^2}$

$\varepsilon = 0.8$ $\alpha = 0.8$

find: K

solution: $KA\left(\frac{T_2 - T_1}{t}\right) = hA(T_\infty - T_2) + \varepsilon A(T_\infty^4 - T_2^4) \quad \alpha \dot{q}_{sun} A$

$$K = \frac{(\alpha \dot{q}_{sun} + h(T_2 - T_1) + \sigma\varepsilon(T_2^4 - T_\infty^4))t}{T_2 - T_1}$$

$$K = \frac{(0.8 \cdot 150 + 8(40 - 44) + 0.8 \cdot 5.67 \times 10^{-8}((313.15)^4 - (317.15)^4))0.25}{44 - 27}$$

$$K = 0.96 \frac{W}{m \cdot K}$$

(17-16) given: $T_\infty = 20^\circ C$ $A = 1.7 m^2$ $T_b = 37^\circ C$

$K_s = 0.3 \frac{W}{mK}$ $\dot{Q}_{out} = 150W$ $t = 0.5cm$

find: T_s

solution:

$$\dot{Q}_{out} = K_s A \left(\frac{T_2 - T_s}{t} \right)$$

$$T_b - \frac{\dot{Q}_{out} t}{K_s A} = T_s$$

$$37 - \frac{150 \cdot 0.005}{0.3 \cdot 1.7} = T_s$$

$$35.5^\circ C = T_s$$

(17-21) given: $A = 1.5\,m^2$ $t_g = 4\,mm$ $K_g = 0.78\,\frac{W}{mK}$

$T_{in} = 26°C$ $h_{in} = 40\,\frac{W}{m^2K}$ $t_a = 5\,mm$ $K_a = 0.026\,\frac{W}{mK}$

$T_{out} = -20°C$ $h_{out} = 20\,\frac{W}{m^2K}$

find: $\dot{Q}_{out}$, ΔT largest R

solution:

$$\dot{Q}_{out} = \frac{T_{in} - T_{out}}{R_{total}}$$

$$R_{total} = \frac{2t_g}{K_g A} + \frac{t_a}{K_a A} + \frac{1}{h_{in} A} + \frac{1}{h_{out} A}$$

$$R_{total} = \frac{2 \cdot 0.004}{0.78 \cdot 1.5} + \frac{0.005}{0.026 \cdot 1.5} + \frac{1}{40 \cdot 1.5} + \frac{1}{20 \cdot 1.5}$$

$$R_{total} = 0.19\,\frac{K}{W}$$

$$\dot{Q}_{out} = \frac{20 + 20}{0.19}$$

$$\boxed{\dot{Q}_{out} = 210.3\,W}$$

$$\dot{Q}_{out} = \frac{\Delta T_{total}}{R_{total}} = \frac{\Delta T_{largest\,R}}{R_{air}}$$

$$\Delta T_{largest\,R} = \dot{Q}_{out} \cdot R_{air}$$

$$= 210.3\,W \cdot \frac{0.005}{0.026 \cdot 1.5}$$

$$\boxed{\Delta T_{largest\,R} = 28.04\,°C}$$

17-43 given: $h_c = 18{,}000 \frac{W}{m^2 K}$

find: L

Solution:

$$K = 401 \frac{W}{mK}$$

$$R_c = \frac{1}{h_c} = 5.56 \times 10^{-5} \frac{m^2 K}{W}$$

$$R = \frac{L}{K}$$

$$L = K \cdot R = 401 \cdot 5.56 \times 10^{-5} = 0.022\ m$$

$$L = 2.2\ cm$$

17-57 given: $L_f = 0.0001\,m$ $L_a = 0.0015\,m$ $T_1 = 28^\circ C$

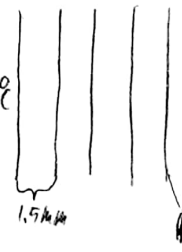
$A = 1.25\,m^2$ $K_f = 0.13 \frac{W}{mK}$ $K_a = 0.026 \frac{W}{mK}$ $T_2 = 0^\circ C$

$h = 25 \frac{W}{m^2 K}$

find: a) $\dot{Q}$ @ $T_2 = 0^\circ C$, b) $\dot{Q}$ @ $L_f = 0.0005\,m$, c) L_w @ $K_w = 0.035 \frac{W}{mK}$

Solution:

a) $T_1 = 28C$ $T_2 = 0^\circ C$



$\dot{Q} = \frac{T_1 - T_2}{R_{total}} = \frac{28}{0.2197} = 127.5\,W$

$R_{total} = \frac{5L_f}{K_f A} + \frac{4L_a}{K_a A} + \frac{1}{h A}$

$R_{total} = \frac{5 \cdot .0001}{0.13 \cdot 1.25} + \frac{4 \cdot 0.0015}{0.026 \cdot 1.25} + \frac{1}{25 \cdot 1.25}$

$R_{total} = 0.2197 \frac{K}{W}$

a) $\dot{Q} = 127.5W$ @ $T = 0^\circ C$

b) $R_{total} = \frac{5 \cdot 0.0005}{0.13 \cdot 1.25} + \frac{4 \cdot 0.0015}{0.026 \cdot 1.25} + \frac{1}{25 \cdot 1.25}$

$R_{total} = 0.232 \frac{K}{W}$

$\dot{Q} = \frac{28}{0.232} = 120.7\,W$

b) $\dot{Q} = 120.7W$ @ $L_f = 0.0005\,m$

c) $\dot{Q} = \frac{\Delta T}{R_{total}} = \frac{\Delta T}{\frac{L_w}{K_w A} + \frac{1}{h_c A}}$

$\frac{L_w}{K_w A} + \frac{1}{h_c A} = \frac{\Delta T}{\dot{Q}}$

$L_w = \frac{\Delta T K_w A}{\dot{Q}} - \frac{K_w}{h_c} = \frac{28 \cdot 0.035 \cdot 1.25}{127.5} - \frac{0.035}{25} = 0.0082\,m$

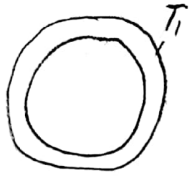
$L_w = 8.2\,mm$

17-70 given: $L = 50\ m$ $d_o = 10\ cm$ $T_\infty = 15^\circ C$ $T_1 = 150^\circ C$
$h = 20 \frac{W}{m^2 K}$

find: a) $\dot{Q}$ b) cost, $\eta = 75\%$ price = \$0.52 $\frac{1}{therm}$ c) t_f, $K_f = 0.035 \frac{W}{mK}$ 90%

Solution:

a)



$A = L \cdot 2\pi r = 50 \cdot 2\pi \cdot 0.05$

$A = 15.71\ m^2$

$\dot{Q} = hA(T_1 - T_\infty) = 20 \cdot 15.71 (150 - 15) = 42{,}411\ W$

a) $\boxed{\dot{Q} = 42.4\ kW}$

b) $\$0.52 \frac{1}{therm} \cdot \frac{therm}{105{,}500\ kJ} = 4.93 \times 10^{-6} \frac{\$}{kJ}$

$\dot{q} = \frac{42.4}{0.75} \frac{kJ}{s} \cdot \frac{3600 s}{hr} \cdot \frac{24 hr}{day} \cdot \frac{365\ days}{year} = 1.34 \times 10^9 \frac{kJ}{year}$

$cost = 4.93 \times 10^{-6} \frac{\$}{kJ} \cdot \frac{1.34 \times 10^9 \frac{kJ}{year}}{0.75} = 8790 \frac{\$}{year}$

b) $\boxed{cost = 8790 \frac{\$}{year}}$

c) $0.1 \cdot \dot{Q} = \frac{T_1 - T_\infty}{R_{total}}$ $R_{total} = \frac{\ln(r_2/r_1)}{2\pi L K_f} + \frac{1}{h 2\pi r_2 L}$ $r_1 = \frac{d}{2}$ $r_2 = t_f + \frac{d}{2}$

$$\boxed{0.1\dot{Q} = \frac{\Delta T}{\frac{\ln\left(\frac{t_f + d/2}{d/2}\right)}{2\pi L K_f} + \frac{1}{h 2\pi L (t_f + \frac{d}{2})}}}$$

matLab

$t = 0.0192\ m$

$\boxed{t = 1.92\ cm}$

```
clear,clc

L = 50;
d = .1;
dT = 150-15;
h = 20;
k = 0.035;
A = L*2*pi*d/2;
Qd = h*A*dT;

for t = 0.001:.0001:.1
    Q = dT/(log((t+d/2)/(d/2))/(2*pi*L*k)+1/(h*2*pi*L*(t+d/2)));
    if abs(Q-0.1*Qd) < 10
        break
    end
end
```

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