47.33 A $4in$ thick composite wall has an R-value of of $8\frac{hr\cdot ft^2\cdot{}^\circ F}{Btu}$. The inside and outside convective heat transfer coefficients are $1.5\frac{Btu}{hr\cdot ft^2\cdot{}^\circ F}$ and $3\frac{Btu}{hr\cdot ft^2\cdot{}^\circ F}$, respectively. What is the total thermal resistance?

A. $0.1\frac{hr\cdot ft^2\cdot{}^\circ F}{Btu}$

B. $0.9\frac{hr\cdot ft^2\cdot{}^\circ F}{Btu}$

C. $1.1\frac{hr\cdot ft^2\cdot{}^\circ F}{Btu}$

D. $9.0\frac{hr\cdot ft^2\cdot{}^\circ F}{Btu}$

The R-value for a Composite Wall is the thermal resistance for all materials from which the wall is composed. Film coefficients are an outcome of the orientation, air velocity, and other fluid characteristics, and not a function of the wall construction. Therefore, when calulating the total thermal resistance, the effect of films must be added separately if they are able to be known. In this case, the film coefficients for inside and outside are both given. Write an expression for the total resistance, substitute, and solve.

$$R_t = \frac{1}{h_i} + R + \frac{1}{h_o}$$

$$R_t = \frac{1}{1.5\frac{Btu}{hr\cdot ft^2\cdot{}^\circ F}} + 8\frac{hr\cdot ft^2\cdot{}^\circ F}{Btu} + \frac{1}{3\frac{Btu}{hr\cdot ft^2\cdot{}^\circ F}} = 9\frac{hr\cdot ft^2\cdot{}^\circ F}{Btu}$$

Answer D

47.34 An object with a surface area of $10ft^2$ and a surface temperature of $40^\circ F$ gains $1000\frac{Btu}{hr}$ through a combination of radiation and convection. The ambient temperature as well as the temperature of the surrounding surfaces is $80^\circ F$. The emmissivity is 0.8. What is the convection film coefficient?

A. $1.7\frac{Btu}{hr\cdot ft^2{}^\circ F}$

B. $3.1\frac{Btu}{hr\cdot ft^2{}^\circ F}$

C. $3.8\frac{Btu}{hr\cdot ft^2{}^\circ F}$

D. $5.6\frac{Btu}{hr\cdot ft^2{}^\circ F}$

Radiation and Convection are both applicable and together make up the total heat gain.

$$\dot{Q}_t = \dot{Q}_{conv} + \dot{Q}_{rad}$$

$$\dot{Q}_{conv} = hA\Delta T$$

$$\dot{Q}_{rad} = \sigma\varepsilon A\left(T_s^4 - T_\infty^4\right)$$

$$\dot{Q}_t = \dot{Q}_{conv} + \dot{Q}_{rad} = hA\Delta T + \sigma\varepsilon A\left(T_s^4 - T_\infty^4\right)$$

Calculate the heat transfer resulting from radiation. Be sure to use absolute temperatures i.e. degrees Rankine.

$$\dot{Q}_{rad} = \sigma\varepsilon A\left(T_s^4 - T_\infty^4\right)$$

$$\dot{Q}_{rad} = \left(0.1713 \times 10^{-8} \frac{Btu}{hr \cdot ft^2{}^\circ R}\right)(0.8)\left(10ft^2\right)\left[(540^\circ R)^4 - (500^\circ R)^4\right] = 308.8\frac{Btu}{hr}$$

Subtract the radiation from the total heat gain to determine the heat gain from convection.

$$\dot{Q}_{conv} = \dot{Q}_t - \dot{Q}_{rad} = 1000\frac{Btu}{hr} - 308.8\frac{Btu}{hr} = 691.2\frac{Btu}{hr}$$

Solve for the convection coefficient.

$$\dot{Q}_{conv} = hA\Delta T$$

$$h = \frac{\dot{Q}_{conv}}{A\Delta T} = \frac{\left(691.2\frac{Btu}{hr}\right)}{\left(10ft^2\right)\left(80^\circ F - 40^\circ F\right)} = 1.7\frac{Btu}{hr \cdot ft^2{}^\circ F}$$

Answer A

47.35 A hot water heat exchanger is supplied with $55^\circ C$ LTHW which is used to heat $2\frac{L}{s}$of domestic water from $20^\circ C$ to $50^\circ C$. The return LTHW temperature is $47^\circ C$. What is the volume flow rate of LTHW required?

A. $0.5\frac{L}{s}$

B. $3.0\frac{L}{s}$

C. $7.5\frac{L}{s}$

D. $11.0\frac{L}{s}$

Assuming 100% efficiency, the heat supplied to the domestic hot water is removed from the low temperature hot water (LTHW). Set these quantities equal and represent each using $Q = \dot{m}c_p\Delta T$.

$$\dot{Q}_{LTHW} = \dot{Q}_{DHW}$$

$$\left[\dot{m}c_p\Delta T\right]_{LTHW} = \left[\dot{m}c_p\Delta T\right]_{DHW}$$