(3)

9.1 A furnace wall is constructed of 7 in. of fire brick ($k = 0.60$ Btu h^{-1} ft^{-1} °F^{-1}), 4 in. of red brick ($k = 0.40$), 1 in. of glass-wool insulation ($k = 0.04$), and $\frac{1}{8}$ in. steel plate ($k = 26$) on the outside. The heat transfer coefficients on the inside and outside surfaces are 9 and 3 Btu h^{-1} ft^{-2} °F^{-1}, respectively. The gas temperature inside the furnace is 2500°F, and the outside air temperature is 90°F.

a) Calculate the heat-transfer rate through the wall (Btu h^{-1} ft^{-2}).
b) Determine the temperatures at all interfaces.

Note the use of Delta F vs F

$T_i := 2500 \cdot F$

T_{i1} $\quad h_i := 9 \cdot \frac{BTU}{hr \cdot ft^2 \cdot \Delta°F}$ $\quad R_i := \frac{1}{h_i}$

T_{12} $\quad L_1 := 7 \cdot in$ $\quad k_1 := 0.60 \cdot \frac{BTU}{hr \cdot ft \cdot \Delta°F}$ $\quad R_1 := \frac{L_1}{k_1}$

T_{23} $\quad L_2 := 4 \cdot in$ $\quad k_2 := 0.40 \cdot \frac{BTU}{hr \cdot ft \cdot \Delta°F}$ $\quad R_2 := \frac{L_2}{k_2}$

T_{34} $\quad L_3 := 1 \cdot in$ $\quad k_3 := 0.04 \cdot \frac{BTU}{hr \cdot ft \cdot \Delta°F}$ $\quad R_3 := \frac{L_3}{k_3}$

T_{4o} $\quad L_4 := \frac{1}{8} \cdot in$ $\quad k_4 := 26 \cdot \frac{BTU}{hr \cdot ft \cdot \Delta°F}$ $\quad R_4 := \frac{L_4}{k_4}$

$T_o := 90 \cdot F$ $\quad h_o := 3 \cdot \frac{BTU}{hr \cdot ft^2 \cdot \Delta°F}$ $\quad R_o := \frac{1}{h_o}$

$R_T := R_i + R_1 + R_2 + R_3 + R_4 + R_o \qquad R_T = (1.449 \cdot 10^3) \frac{s \cdot \Delta°F \cdot m^2}{BTU}$

$q := \frac{(T_i - T_o) \cdot \frac{\Delta°F}{F}}{R_T} = 556.102 \frac{BTU}{ft^2 \cdot hr}$

$T_i = 2500\ F$

$T_{i1} := T_i - q \cdot R_i \cdot \frac{F}{\Delta°F} = 2438.2\ F$

$T_{12} := T_{i1} - q \cdot R_1 \cdot \frac{F}{\Delta°F} = (1.9 \cdot 10^3)\ F$

$T_{23} := T_{12} - q \cdot R_2 \cdot \frac{F}{\Delta°F} = (1.4 \cdot 10^3)\ F$

$T_{34} := T_{23} - q \cdot R_3 \cdot \frac{F}{\Delta°F} = 275.59\ F$

$T_{4o} := T_{34} - q \cdot R_4 \cdot \frac{F}{\Delta°F} = 275.37\ F$

$T_o := T_{4o} - q \cdot R_o \cdot \frac{F}{\Delta°F} = 90\ F$