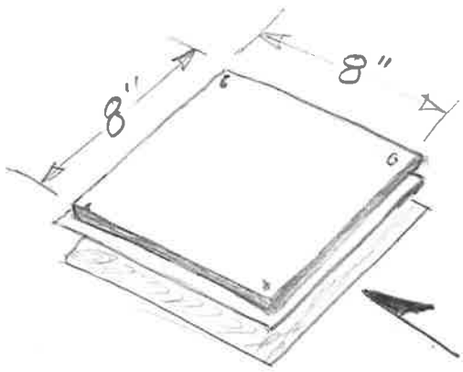
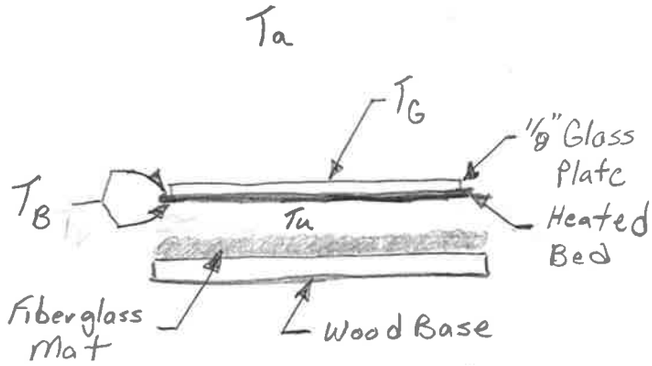




T_a - temp Ambient in box
T_G - temp at glass surface
T_B - temp of Bed, termistor reading
T_u - temp under bed

Above plate

Overall temp change $T_B - T_a$

Steady state heat transfer for flat plate

$q = BTU/hr = \frac{kA\Delta T}{\Delta X}$; k - thermal cond., A - plate area, ΔT - temp change, ΔX - plate thickness

$q_G = \frac{k_g A(T_B - T_G)}{\Delta X_G}$; Heat Transfer rate through glass

Radiation + convection from glass plate

$q_{R+C} = h_a A (T_G - T_a)$

$q_G = q_{R+C} \Rightarrow \frac{k_g A (T_B - T_G)}{\Delta X_G} = h_a A (T_G - T_a)$

$k_g T_B - k_g T_G = \Delta X_G h_a T_G - \Delta X_G h_a T_a$

$k_g T_B + \Delta X_G h_a T_a = \Delta X_G h_a T_G + k_g T_G$

$k_g T_B + \Delta X_G h_a T_a = T_G (\Delta X_G h_a + k_g)$

$T_G = \frac{k_g T_B + \Delta X_G h_a T_a}{\Delta X_G h_a + k_g}$

$k_g = 0.455\ BTU/hr \cdot ft^2 (F/ft_T)$

$T_B = 110°C = 230°F$

$T_a = 80°F$

$\Delta x_G = 0.125\ in = 0.0104\ ft$

$h_a = 2.7\ BTU/hr\ ft^2 F$

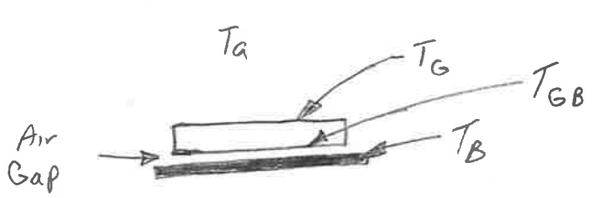
$$T_G = \frac{(0.455\ BTU/hr\ ft^2 F/ft_T)(230F) + (0.0104 ft_T)(2.7\ BTU/hr\ ft^2 F)(80F)}{(0.0104 ft_T)(2.7\ BTU/hr\ ft^2 F) + 0.455\ BTU/hr\ ft^2\ F/ft_T}$$

$$\frac{(0.455)(230)+(0.0104)(2.7)(80)}{(0.0104)(2.7)+0.455}$$

$$\frac{\frac{BTU \cdot ft_T}{hr\ ft^2}}{\frac{BTU\ ft_T}{hr\ ft^2 F}}$$

$$\frac{104.65+2.2464}{0.02808+0.455}\ F$$

$$\frac{106.8964}{0.48308} = 221.3F = 105°C$$



T_{GB} = temp at glass bottom ; ΔX_{Gap} = air gap between bed & glass

$$q = \frac{k_{air} A (T_B - T_{GB})}{\Delta X_{Gap}} = \frac{k_g A (T_{GB} - T_G)}{\Delta X_G} = h_a A (T_G - T_a)$$

From the prior calc :

$$T_G = \frac{k_g T_{GB} + \Delta X_G h_a T_a}{\Delta X_G h_a + k_g} \quad (1)$$

we don't know T_{GB} so we need another equation

$$\frac{k_{air} A (T_B - T_{GB})}{\Delta X_{Gap}} = \frac{k_g A (T_{GB} - T_G)}{\Delta X_G}$$

$$k_{air} (T_B - T_{GB}) = \frac{\Delta X_{Gap}}{\Delta X_G} k_g (T_{GB} - T_G)$$

$$k_{air} T_B - k_{air} T_{GB} = \frac{\Delta X_{Gap}}{\Delta X_G} k_g T_{GB} - \frac{\Delta X_{Gap}}{\Delta X_G} k_g T_G$$

$$k_{air} T_B + \frac{\Delta X_{Gap}}{\Delta X_G} k_g T_G = \frac{\Delta X_{Gap}}{\Delta X_G} k_g T_{GB} + k_{air} T_{GB}$$

$$k_{air} T_B + \frac{\Delta X_{Gap}}{\Delta X_G} k_g T_G = \left[\frac{\Delta X_{Gap}}{\Delta X_G} k_g + k_{air}\right] T_{GB}$$

$$T_{GB} = 1 \Big/ \left[\frac{\Delta X_{Gap}}{\Delta X_G} k_g + k_{air}\right] \left\{ k_{air} T_B + \frac{\Delta X_{Gap}}{\Delta X_G} k_g T_G \right\} \quad (2)$$

Let $C = 1 \Big/ \left[\frac{\Delta X_{Gap}}{\Delta X_G} k_g + k_{air}\right]$

Sub (2) in to (1)

$$T_G = \frac{k_g \left[C \cdot \left(k_{air} T_B + \frac{\Delta X_{Gap}}{\Delta X_G} k_g T_G\right)\right] + \Delta X_G h_a T_a}{\Delta X_G h_a + k_g}$$

$$T_G = \frac{k_g C k_{air} T_B + k_g C \frac{\Delta X_{Gap}}{\Delta X_G} k_g T_G + \Delta X_G h_a T_a}{\Delta X_G h_a + k_g}$$

$$D = \Delta X_G h_a + k_g$$

$$T_G = \frac{k_g C k_{air} T_B + k_g C \frac{\Delta X_{Gap}}{\Delta X_G} k_g T_G + \Delta X_G h_a T_a}{P}$$

$$T_G - k_g \frac{C}{D} \frac{\Delta X_{Gap}}{\Delta X_G} k_g T_G = k_g \frac{C}{D} k_{air} T_B + \frac{\Delta X_G}{D} h_a T_a$$

$$T_G = \frac{k_g \frac{C}{D} k_{air} T_B + \frac{\Delta X_G}{D} h_a T_a}{1 - k_g \frac{C}{D} \frac{\Delta X_{Gap}}{\Delta X_G} k_g}$$

$k_g = 0.455\ BTU/hr \cdot ft^2 \cdot (F/ft)$

$T_B = 110°C = 230°F$

$T_a = 80°F$

$\Delta X_G = 0.125 in = 0.0104 ft$

$h_a = 2.7\ BTU/hr\,ft^2\,°F$

$\Delta X_{Gap} = 0.5 mm = 0.00164 ft$

$k_{air} = 0.0183\ BTU/hr\,ft^2(F/ft)$

$$C = \frac{1}{\left[\left(\frac{0.00164 ft}{0.0104 ft}\right)(0.455\ BTU/hr \cdot ft^2 \cdot (F/ft) + 0.0183\ BTU/hr\,ft^2(F/ft)\right]}$$

$$C = 11.1049\ \frac{hr\,ft^2(F/ft)}{BTU}$$

$$D = (0.0104 ft)(2.7\ BTU/hr\,ft^2\,°F) + 0.455\ BTU/hr \cdot ft^2(F/ft)$$

$$D = 0.48308\ BTU/hr\,ft^2(F/ft)$$

$$k_g \frac{C}{D} k_{air} T_B = (0.455\ BTU/hr\,ft^2(F/ft)) \frac{11.1049\ \frac{hr\,ft^2(F/ft)}{BTU}}{0.48308\ BTU/hr\,ft^2(F/ft)} (0.0183\ BTU/hr\,ft^2(F/ft)) \times 230F$$

$$k_g \frac{C}{D} k_{air} T_B = 44.024°F$$

$$\frac{\Delta X_G}{D} h_a T_a = \frac{(0.0104 ft)}{0.48308\ BTU/hr\,ft^2(F/ft)} (2.7\ BTU/hr\,ft^2 F)(80°F)$$

$$\frac{\Delta X_G}{D} h_a T_a = 4.65°F$$

$$k_g \frac{C}{D} \frac{\Delta X_{Gap}}{\Delta G_G} k_g = (0.455\ BTU/hr\,ft^2(F/ft)) \frac{11.1049\ \frac{hr\,ft^2(F/ft)}{BTU}}{0.48308\ \frac{BTU}{hr\,ft^2(F/ft)}} (0.455\ BTU/hr\,ft^2(F/ft)) \frac{0.00164}{0.0104}$$

$$= 0.75$$

$$T_G = \frac{44.024°F + 4.65°F}{1 - 0.75} = 194.7°F = 90.4°C$$