



Mathematical Modelling of a Box Type Solar Cooker Incorporating Contact Resistance

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APPENDIX-I

$$Q_{uf} = Q_t + Q_b \quad \dots (A1)$$

Useful heat gained from the top can be given by

$$Q_{t,u} = S.A_f - U_L.A_f(T_L - T_a) \quad \dots (A2)$$

Where $U_L.A_f(T_L - T_a)$ is the heat loss from the lid of the vessel.

Useful heat gained from the bottom can be given by

$$Q_{b,u} = X.A_f.S - U_L.X.A_f(T_{pm} - T_a) \quad \dots (A3)$$

Hence placing the value of Eq. (A2) and Eq. (A3) into Eq. (A1),

$$Q_{uf} = S.A_f - U_L.A_f.(T_L - T_a) + X.A_f.S - U_L.X.A_f(T_{pm} - T_a) \quad \dots (A4)$$

Now

$$Q_{b,u} = A_f.h_{ct}.(T_{pm} - T_L) \quad \dots (A5)$$

Equating Eq. (A3) and Eq. (A5),

$$X.A_f.S - U_L.X.A_f.T_{pm} + U_L.X.A_f.T_a = A_f.h_{ct}T_{pm} - A_f.h_{ct}.T_L$$

$$X.A_f.S + U_L.X.A_f.T_a + A_f.h_{ct}.T_L = A_f.T_{pm}(X.U_L + h_{ct})$$

Dividing by $A_f.(X.U_L + h_{ct})$, we get

$$\frac{X.S}{(X.U_L + h_{ct})} + \frac{U_L.X.T_a}{(X.U_L + h_{ct})} + \frac{h_{ct}}{(X.U_L + h_{ct})}.T_L = T_{pm}$$

$$X_1.S + X_2.T_a + X_3.T_L = T_{pm} \quad \dots (A6)$$

$$\text{Where, } X_1 = \frac{X}{(X.U_L + h_{ct})} \quad \dots (A6.1)$$

$$X_2 = \frac{U_L.X}{(X.U_L + h_{ct})} \quad \dots (A6.2)$$

$$X_3 = \frac{h_{ct}}{(X.U_L + h_{ct})} \quad \dots (A6.3)$$

Substituting value of T_{pm} from Eq. (A6) in Eq. (A4), we get

$$Q_{uf} = S.A_f - U_L.A_f.(T_L - T_a) + X.A_f.S - U_L.X.A_f.(X_1.S + X_2.T_a + X_3.T_L) + U_L.X.A_f.T_a$$

$$Q_{uf} = S.A_f - U_L.A_f.T_L + U_L.A_f.T_a + X.A_f.S - U_L.X.A_f.X_1.S - U_L.X.A_f.X_2.T_a$$

$$- U_L.X.A_f.X_3.T_L + U_L.X.A_f.T_a$$

$$Q_{uf} = S[A_f + X.A_f - U_L.X.A_f.X_1] + T_a[U_L.A_f - U_L.X.A_f.X_2 + U_L.X.A_f] - T_L[U_L.A_f + U_L.X.A_f.X_3]$$

$$Q_{uf} = X_4.S + X_5.T_a - X_6.T_L \quad \dots (A7)$$

Where,

$$X_4 = [A_f + X.A_f - U_L.X.A_f.X_1] \quad \dots (A7.1)$$

$$X_5 = [U_L.A_f - U_L.X.A_f X_2 + U_L.X.A_f] \quad \dots \text{(A7.2)}$$

$$X_6 = [U_L.A_f + U_L.X.A_f X_3] \quad \dots \text{(A7.3)}$$

Considering heat transfer between vessel lid and the food from bottom

$$Q_{b,u} = h_f.A_f.(T_L - T_f) \quad \dots \text{(A8)}$$

Equating Eq. (A8) with Eq. (A3), we get

$$h_f.A_f.(T_L - T_f) = X.A_f.S - U_L.X.A_f.T_{pm} + U_L.X.A_f.T_a \quad \dots \text{(A9)}$$

Substituting for T_{pm} from Eq. (A6),

$$\begin{aligned} h_f.A_f.T_L - h_f.A_f.T_f &= X.A_f.S - U_L.X.A_f(X_1.S + X_2.T_a + X_3.T_L) + U_L.X.A_f.T_a \\ &= X.A_f.S - U_L.X.A_f.X_1.S - U_L.X.A_f.X_2.T_a - U_L.X.A_f.X_3.T_L + U_L.X.A_f.T_a \\ (h_f.A_f + U_L.X.A_f.X_3)T_L &= h_f.A_f.T_f + X.A_f.S - U_L.X.A_f.X_1.S - U_L.X.A_f.X_2.T_a + U_L.X.A_f.T_a \end{aligned}$$

$$X_7.T_L = [X.A_f - U_L.X.A_f X_1] S - [U_L.X.A_f X_2 - U_L.X.A_f] T_a + h_f.A_f T_f \quad \dots \text{(A10)}$$

Where,

$$X_7 = (h_f.A_f + U_L.X.A_f X_3) \quad \dots \text{(A10.1)}$$

$$X_8 = [X.A_f - U_L.X.A_f.X_1] / X_7 \quad \dots \text{(A10.2)}$$

$$X_9 = [U_L.X.A_f X_2 - U_L.X.A_f] / X_7 \quad \dots \text{(A10.3)}$$

$$X_{10} = h_f.A_f / X_7 \quad \dots \text{(A10.4)}$$

Substituting value of T_L from Eq. (A10) in Eq. (A6),

$$T_{pm} = X_1.S + X_2.T_a + X_3.X_8.S - X_3.X_9.T_a + X_3.X_{10}.T_f$$

$$T_{pm} = (X_1 + X_3.X_8) S - (X_3.X_9 - X_2) T_a + X_3.X_{10}.T_f$$

$$T_{pm} = X_{11}S - X_{12}T_a + X_{13}T_f \quad \dots \text{(A11)}$$

$$\text{Where, } X_{11} = X_1 + X_3.X_8 \quad \dots \text{(A11.1)}$$

$$X_{12} = X_3.X_9 - X_2 \quad \dots \text{(A11.2)}$$

$$X_{13} = X_3.X_{10} \quad \dots \text{(A11.3)}$$

Substituting values of T_L and T_{pm} from Eq. (A10) and Eq. (A11) in Eq. (A4),

$$Q_{uf} = S.A_f - U_L.A_f.(X_8.S - X_9.T_a + X_{10}.T_f) + U_L.A_f.T_a + X.A_f.S$$

$$- U_L.X.A_f.(X_{11}S - X_{12}T_a + X_{13}T_f) + U_L.X.A_f.T_a$$

$$Q_{uf} = S.A_f - U_L.A_f.X_8.S + U_L.A_f.X_9.T_a - U_L.A_f.X_{10}.T_f + U_L.A_f.T_a + X.A_f.S$$

$$- U_L.X.A_f.X_{11}S + U_L.X.A_f.X_{12}T_a - U_L.X.A_f.X_{13}T_f + U_L.X.A_f.T_a$$

$$Q_{uf} = [A_f - U_L.A_f.X_8 - U_L.X.A_f.X_{11} + X.A_f]S - [U_L.A_f.X_{10} + U_L.X.A_f.X_{13}]T_f$$

$$+ [U_L.A_f.X_9 + U_L.A_f + U_L.X.A_f.X_{12} + U_L.X.A_f]T_a$$

$$Q_{uf} = X_{14}.S - X_{15}.T_f + X_{16}.T_a \quad \dots \text{(A12)}$$

where,

$$X_{14} = A_f - U_L.A_f.X_8 - U_L.X.A_f.X_{11} + X.A_f \quad \dots \text{(A12.1)}$$

$$X_{15} = U_L.A_f.X_{10} + U_L.X.A_f.X_{13} \quad \dots \text{(A12.2)}$$

$$X_{16} = U_L.A_f.X_9 + U_L.A_f + U_L.X.A_f.X_{12} + U_L.X.A_f \quad \dots \text{(A12.3)}$$

Equating Eq. (A12) with Eq. (3) in the main body, we get

$$Q_{uf} = X_{14}.S - X_{15}.(T_f + \frac{X_{16}}{X_{15}}.T_a) = M.c_{pf} \frac{dT_f}{dt} \quad \dots \text{(A13)}$$