Rearrange Equation to have $\frac{T_3+T_1}{2}$ on Left side of each equation.

$$Q_a = m_a C_{pa}(T_3 - T_1) + \frac{\left(\frac{T_3+T_1}{2} - \frac{T_2+T_0}{2}\right)}{R_{pipe}} - \frac{\left(\frac{T_3+T_1}{2} - T_{int}\right)}{R_{int}} - \frac{\left(\frac{T_3+T_1}{2} - T_{ext}\right)}{R_{ext}}$$

$$T_3\left[m_a C_{pa} + \tfrac{1}{2}R_{pipe} - \frac{1}{2R_{int}} - \frac{1}{2R_{ext}}\right] = A_{23}$$

$$T_2\left[\frac{-1}{2R_{pipe}}\right] = A_{22}$$

$$= T_1\left[m_a C_{pa} - \frac{1}{2R_{pipe}} + \frac{1}{2R_{int}} + \frac{1}{2R_{ext}}\right] + T_0\left[\frac{1}{2R_{pipe}}\right] + T_{int}\left[-1/R_{int}\right] + T_{ext}\left[-1/R_{ext}\right]$$

$$= F_2$$

$$Q_a = m_a C_{pa}(T_3 - T_1) + \frac{\left(\frac{T_3+T_1}{2} - \frac{T_2+T_o}{2}\right)}{R_{pipe}} + \frac{\left(\frac{T_3+T_1}{2} - T_{int}\right)}{R_{int}} + \frac{\left(\frac{T_3+T_1}{2} - T_{ext}\right)}{R_{ext}}$$

$$T_3\left[m_a C_{pa} + \tfrac{1}{2}R_{pipe} + \frac{1}{2R_{int}} + \frac{1}{2R_{ext}}\right] = A_{23}$$

$$T_2\left[\frac{-1}{2R_{pipe}}\right] = A_{22}$$

$$= T_1\left[m_a C_{pa} - \frac{1}{2R_{pipe}} - \frac{1}{2R_{int}} - \frac{1}{2R_{ext}}\right] + T_o\left[\frac{1}{2R_{pipe}}\right] + T_{int}\left[\frac{1}{R_{int}}\right] + T_{ext}\left[\frac{1}{R_{ext}}\right]$$

$$= F_2$$

$$Q_a = m_a C_{pa}(T_3 - T_1) - \frac{\left(\frac{T_3+T_1}{2} - \frac{T_2+T_0}{2}\right)}{R_{pipe}} + \frac{\left(\frac{T_3+T_1}{2} - T_{int}\right)}{R_{int}} + \frac{\left(\frac{T_3+T_1}{2} - T_{ext}\right)}{R_{ext}}$$

$$T_3\left[m_a C_{pa} - \tfrac{1}{2}R_{pipe} + \frac{1}{2R_{int}} + \frac{1}{2R_{ext}}\right] = A_{23}$$

$$T_2\left[\frac{1}{2R_{pipe}}\right] = A_{22}$$

$$= T_1\left[m_a C_{pa} + \frac{1}{2R_{pipe}} - \frac{1}{2R_{int}} - \frac{1}{2R_{ext}}\right] + T_0\left[\frac{1}{2R_{pipe}}\right] + T_{int}\left[\frac{1}{R_{int}}\right] + T_{ext}\left[\frac{1}{R_{ext}}\right]$$

$$= T_2$$

Use original equation but reverse sign on Q_w

$$Q_w = m_w C_{pw}(T_2 - T_0) + \frac{\left(\frac{T_3+T_1}{2} - \frac{T_2+T_1}{2}\right)}{R_{pipe}}$$

$$A_{12} = \left[m_w C_{pw} - \frac{1}{2R_{pipe}}\right]$$

$$A_{13} = \frac{1}{2R_{pipe}}$$

Observation: Any changes to the signs around $\frac{1}{2R_{pipe}}$ have very minimal change to the result. The drivers are $m \cdot C_p$ and R_{int}/R_{ext}.

Resistance of glass layers only include cond. Should add internal convection.....

Post adding convection to glass resistance:

* T[3] = 28.8°C
  → Better but still does not make sense, when max Temp is 25°C

✓

Attempt to randomly change sign on T_{int} or T_{ext} only, at once

$$Q_w = m_w C_{pw}(T_2 - T_0) - \frac{\left(\frac{T_3+T_1}{2} - \frac{T_2+T_0}{2}\right)}{R_{pipe}}$$ (Stays the same)

$$Q_a = m_a C_{pa}(T_3 - T_1) + \frac{\left(\frac{T_3+T_1}{2} - \frac{T_2+T_0}{2}\right)}{R_{pipe}} - \frac{\left(T_{int} - \frac{(T_3+T_1)}{2}\right)}{R_{int}} + \frac{\left(T_{ext} - \frac{(T_3+T_1)}{2}\right)}{R_{ext}}$$

$$A_{23} = T_3\left[m_a C_{pa} + \frac{1}{2R_p} + \frac{1}{2R_i} - \frac{1}{2R_e}\right]$$

$$A_{22} = T_2\left[-\frac{1}{2R_p}\right]$$

$$F_2 = T_0\left[\frac{1}{2R_p}\right] + T_1\left[m_a C_{pa} - \frac{1}{2R_p} - \frac{1}{2R_i} + \frac{1}{2R_e}\right] + T_i\left[\frac{1}{R_{int}}\right] + T_e\left[-\frac{1}{R_{ext}}\right]$$

$T_2 = 15.259$

$T_3 = 31.925$

These numbers still don't check out....

Attempt to randomly change sign on T_{int} or T_{ext}, only, at once

$$Q_w = m_w C_{pw}(T_2 - T_0) - \frac{\left(\frac{T_3+T_1}{2} - \frac{T_2+T_0}{2}\right)}{R_{pipe}} \quad \text{(Stays the same)}$$

$$Q_a = m_a C_{pa}(T_3 - T_1) + \frac{\left(\frac{T_3+T_1}{2} - \frac{T_2+T_0}{2}\right)}{R_{pipe}} + \frac{\left(T_{int} - \frac{(T_3+T_1)}{2}\right)}{R_{int}} - \frac{\left(T_{ext} - \frac{(T_3+T_1)}{2}\right)}{R_{ext}}$$

$$A_{23} = T_3\left[m_a C_{pa} + \frac{1}{2R_p} - \frac{1}{2R_i} + \frac{1}{2R_e}\right]$$

$$A_{22} = T_2\left[-\frac{1}{2R_p}\right]$$

$$F_2 = T_0\left[\frac{1}{2R_p}\right] + T_1\left[m_a C_{pa} - \frac{1}{2R_p} + \frac{1}{2R_i} - \frac{1}{2R_e}\right] + T_i\left[-\frac{1}{R_{int}}\right] + T_e\left[\frac{1}{R_{ext}}\right]$$

$T_2 = 15.11$

$T_3 = 30.25$

These numbers still don't check out....

Taking a step away from messing with signs to rethink the equations.

Reversing sign on $-q_{wa}$

$$Q_a = m_a C_{pa}(T_3 - T_1) - \frac{\left(\frac{T_3+T_1}{2} - \frac{T_2+T_0}{2}\right)}{R_{pipe}} - \frac{\left(T_{int} - \frac{(T_3+T_1)}{2}\right)}{R_{int}} - \frac{\left(T_{ext} - \frac{(T_3-T_1)}{2}\right)}{R_{ext}}$$

$$A_{22} = T_2\left[\frac{1}{2R_p}\right]$$

$$A_{23} = T_3\left[m_a C_{pa} - \frac{1}{2R_{pipe}} + \frac{1}{2R_{int}} + \frac{1}{2R_{ext}}\right]$$

$$F_2 = T_0\left[-\frac{1}{2R_p}\right] + T_1\left[m_a C_{pa} + \frac{1}{2R_{pipe}} - \frac{1}{2R_{int}} - \frac{1}{2R_{ext}}\right] + T_{int}\left[\frac{1}{R_{int}}\right] + T_{ext}\left[\frac{1}{R_{ext}}\right]$$

$T_2 = 14.98$

$T_3 = 28.80$

Still no good ...

Let's double check MatLab code