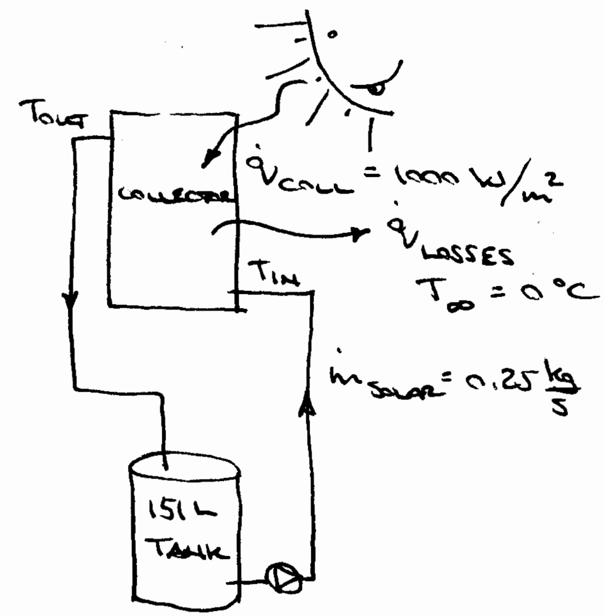
SOLAR STORAGE WARMING TIME SOLUTION



NOTE THIS IS A CONSTANT POWER PROBLEM.

IT IS NOT LIKE THE EGG WHERE THERE IS AN UPPER LIMIT ON THE EGG'S TEMPERATURE (100 °C).

SO $\frac{T - T_\infty}{T_i - T_\infty} = e^{-\frac{h A_s}{\rho V C_p} t}$ DOES NOT APPLY.

$$\dot{q}_{WATER} = \dot{q}_{COLL} - \dot{q}_{LOSSES}$$

$$\dot{q}_{LOSSES} = \frac{T_{COLL} - T_\infty}{R_o}$$

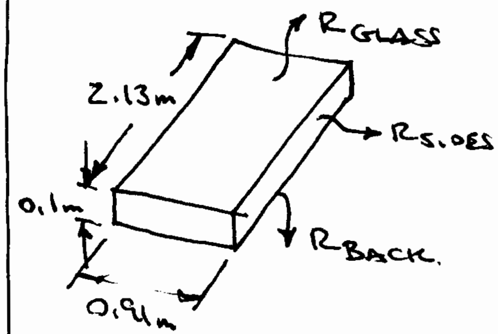
$$T_{COLL} = \frac{T_{OUT} + T_{IN}}{2}$$

$$\dot{q}_{WATER} = \dot{m}_{SOLAR}\, C_p\, (T_{OUT} - T_{IN})$$

ALSO

$$\dot{q}_{WATER} = m_{TANK}\, C_p\, \frac{(T_{END} - T_{START})}{t_{WARMING}}$$

ESTABLISH R_o FOR THE COLLECTOR.



$R_{GLASS} \gg R_{BACK}$ OR R_{SIDES}

$\therefore$ ONE CAN APPROXIMATE THE HEAT LOSS BY JUST USING THE GLASS!

BUT I MISSED SOMETHING AHH!

THE CONVECTIVE AIR FILMS h_i & h_o.

BAD ME ... I BETTER DO THIS.

$$A_{GLASS} = A_{BACK} = 1.93\ m^2$$

$$A_{SIDES} = 0.61\ m^2$$

$$R_o = \frac{1}{\frac{1}{R_{GL}} + \frac{1}{R_{SI}} + \frac{1}{R_{BA}}}$$

$$R_{GLASS} = \frac{L}{KA} = \frac{6 \times 10^{-3}}{0.96 \times 1.93} = 0.003\ \frac{°C}{W}\ \text{(SMALL)}$$

$$R_{BACK} = \frac{70 \times 10^{-3}}{0.04 \times 1.93} = 0.907\ \frac{°C}{W}\ \text{(BIG)}$$

$$R_{SIDES} = \frac{70 \times 10^{-3}}{0.04 \times 0.61} = 2.87\ \frac{°C}{W}\ \text{(BIG)}$$

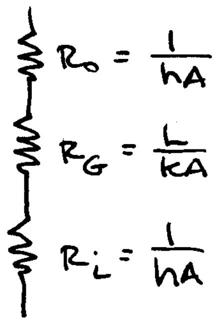
$$\therefore R_o = 0.0029\ \frac{°C}{W}$$

NOTE

$$\dot{q}_{COLL} = 1000\ \frac{W}{m^2} \times 1.93\ m^2$$

$$\dot{q}_{COLL} = 1930\ W$$

REALLY THE GLASS LOOKS LIKE ...



ASSUME $h_o = 25\ W/m^2 \cdot °C$ (SLIGHTLY MOVING AIR)

$h_i = 2\ W/m^2 \cdot °C$ (ALMOST STILL AIR)

SO $R_{GLASS} = \frac{1}{(25)(1.93)} + 0.003 + \frac{1}{(2)(1.93)}$

$= 0.021 + 0.003 + 0.259$

$= 0.283\ \frac{°C}{W}$

GOODNESS THE AIR MAKES A BIG DIFFERENCE !

NOW: $\dot{q}_{LOSSES} = \frac{T_{COLL} + T_{\infty}}{R_o}$

HEY DOESN'T T_{COLL} CHANGE AS THE TANK WARMS ?

WHAT TO DO?

SIMPLE ... SAY

$\left. \begin{array}{l} T_{START} = 10°C \\ T_{END} = 90°C \end{array} \right\} \quad T_{COLL} = \frac{90 + 10}{2} = 50°C$

AS THE WATER & COLLECTER TEMPERATURE RISE IS MORE OR LESS LINEAR OVER TIME ($\dot{q}_s$ = CONST.) THIS IS MORE OR LESS A TRUE AVERAGE CONDITION.

SO ... $\dot{q}_{LOSSES} = \frac{50 - 0}{0.283} = 176.7$ WATTS

$\therefore \dot{q}_{WATER} = \dot{q}_{COLL} - \dot{q}_{LOSSES} = 1930 - 176.7$

$= 1,753.3$ WATTS.

NOW

$t_{WARMING} = m_{TANK}\, C_p \frac{(T_{END} - T_{START})}{\dot{q}_{WATER}}$

$= 151\,kg \cdot 4181 \cdot \frac{(90 - 10)}{1753.3}$

$= 28,806\ s$

$= 8.0$ HOURS.

THAT IS ASSUMING NO WATER FROM THE TANK IS USED.

COLLECTER EFFICIENCY

$\eta_{COLL} = \frac{OUTPUT}{INPUT} = \frac{1753.3}{1930} = 90.8\%$

VERY GOOD.