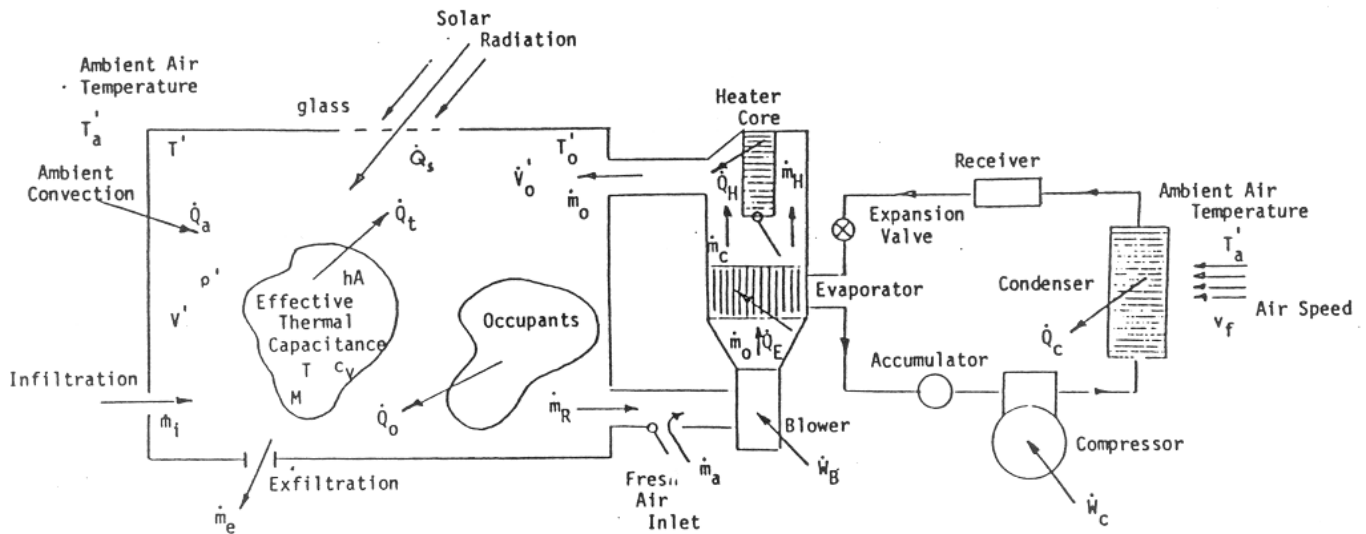


ALTERNATIVE ENERGY SYSTEMS
ME 4530/5530
Homework #3

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Automotive Climate Control

1. Blend-door Temperature Control

- a) If the average air temperature leaving the evaporator and heater core are T_C' and T_H' , respectively, perform an energy analysis and show that the air temperature leaving the dash board registers, T_O' , can be expressed as:

$$T_O' = T_C' + \left(\frac{\dot{m}_H}{\dot{m}_O}\right)(T_H' - T_C')$$

- b) If T_C' and T_H' are 50 and 140°F, respectively, plot the outlet temperature, T_O' , as a function of mass flowrate ratio, $\left(\frac{\dot{m}_H}{\dot{m}_O}\right)$, which can be controlled by blend-door position.

2. If during a hot summer day, a car having the following parameters:

$$T_a' = 100^\circ\text{F}, U_o A_o = 1.25 \text{ Btu/min}^\circ\text{F}, (hA) = 2.0 \text{ Btu/min}^\circ\text{F},$$

Is allowed to sit in a parking lot without shade and reach steady-state, what will the air and internal mass temperatures reach with a solar load of 50 Btu/min?

$$\text{Ans: } T_i' = 140^\circ\text{F}, T_i = 165^\circ\text{F}$$

3. If the same car as above was modified to be a hatch-back with a sun roof, and thus the solar load went up to 65 Btu/min, what would the initial temperatures become?

$$\text{Ans: } T_i' = 152^\circ\text{F}, T_i = 184.5^\circ\text{F}$$

4. Summer cool-down

- a) A car soaks in the hot sun for enough time to reach steady-state. Using the simplified model developed in class, predict the initial temperature, T_i' , and the summer cool-down transient, $T' = T'(t)$, for $0 \leq t \leq 60$ min for the following parameters:

$$T_o' = 50^\circ\text{F}$$

$$T_a' = 100^\circ\text{F}$$

$$Q_o = 0$$

$$Q_s = 2500 \text{ Btu/hr}$$

$$V_o' = 250 \text{ ft}^3/\text{min}$$

$$U_o A_o = 50 \text{ Btu/hr}^\circ\text{F}$$

$$M = 125 \text{ lb}_m$$

$$c_v = 0.3 \text{ Btu/lb}_m^\circ\text{F}$$

$$V' = 250 \text{ ft}^3$$

$$\rho', c_p' = \text{look up at appropriate temperature}$$

Make a graph of the above cool-down.

- b) Repeat the above but with four adult occupants ($N = 4$), $Q_o = N(400) \text{ Btu/hr}$.
- c) What would the air flowrate, V_o' , have to be increased to in order to have a similar performance to that with no occupants?

Note: Superimpose so that all three cool-down curves are on the same graph. Label carefully and completely, and clearly designate the three different curves.

5. Winter warm-up:

- a) A car sits outside all night. Use the model to predict for a cloudy day the winter warm-up transient, $T' = T'(t)$, for $0 \leq t \leq 60$ min for the following parameters:

$$T_o' = 130^\circ\text{F}$$

$$T_a' = 0^\circ\text{F}$$

$$Q_o = 0$$

$$Q_s = 0 \text{ Btu/hr}$$

$$V_o' = 250 \text{ ft}^3/\text{min}$$

$$U_o A_o = 50 \text{ Btu/hr}^\circ\text{F}$$

$$M = 125 \text{ lb}_m$$

$$c_v = 0.3 \text{ Btu/lb}_m^\circ\text{F}$$

$$V' = 250 \text{ ft}^3$$

$$\rho', c_p' = \text{look up at appropriate temperature}$$

- b) Repeat the above for four occupants.

Note: Label and plot both curves on one graph.