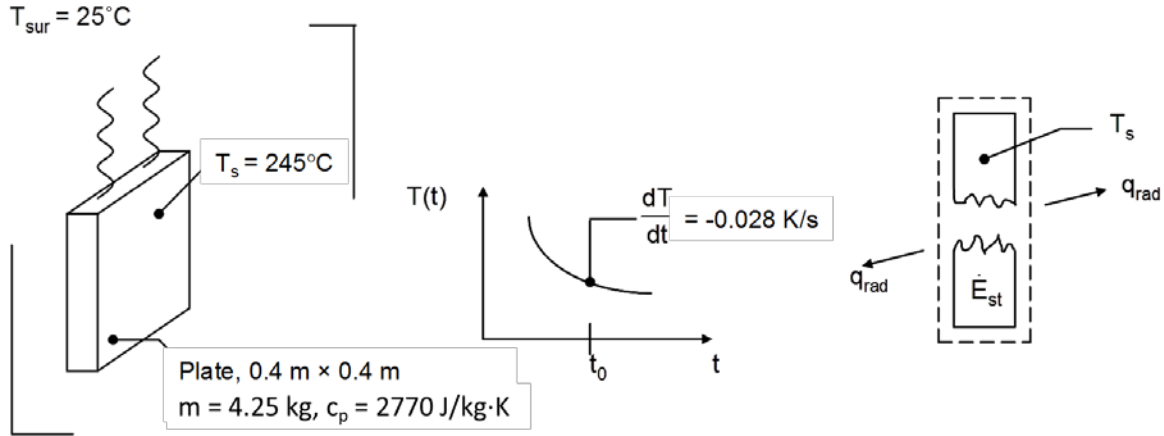


PROBLEM 1.26

KNOWN: Hot plate suspended in vacuum and surroundings temperature. Mass, specific heat, area and time rate of change of plate temperature.

FIND: (a) The emissivity of the plate, and (b) The rate at which radiation is emitted from the plate.

SCHEMATIC:



ASSUMPTIONS: (1) Plate is isothermal and at uniform temperature, (2) Large surroundings, (3) Negligible heat loss through suspension wires.

ANALYSIS: For a control volume about the plate, the conservation of energy requirement is

$$\dot{E}_{in} - \dot{E}_{out} = \dot{E}_{st} \quad (1)$$

$$\text{where } \dot{E}_{st} = mc_p \frac{dT}{dt} \quad (2)$$

$$\text{and for large surroundings } \dot{E}_{in} - \dot{E}_{out} = A\epsilon\sigma(T_{sur}^4 - T_s^4) \quad (3)$$

Combining Eqns. (1) through (3) yields

$$\epsilon = \frac{mc_p}{A\sigma} \frac{\frac{dT}{dt}}{(T_{sur}^4 - T_s^4)}$$

Noting that T_{sur} = 25°C + 273 K = 298 K and T_s = 245°C + 273 K = 518 K, we find

$$\epsilon = \frac{4.25 \text{ kg} \times 2770 \frac{\text{J}}{\text{kg} \cdot \text{K}} \times (-0.028 \frac{\text{K}}{\text{s}})}{2 \times 0.4 \text{ m} \times 0.4 \text{ m} \times 5.67 \times 10^{-8} \frac{\text{W}}{\text{m}^2 \cdot \text{K}^4} (298^4 - 518^4) \text{ K}^4} = 0.28 <$$

The rate at which radiation is emitted from the plate is

$$q_{rad,e} = \epsilon A \sigma T_s^4 = 0.28 \times 2 \times 0.4 \text{ m} \times 0.4 \text{ m} \times 5.67 \times 10^{-8} \frac{\text{W}}{\text{m}^2 \cdot \text{K}^4} \times (518 \text{ K})^4 = 370 \text{ W} <$$

COMMENTS: Note the importance of using kelvins when working with radiation heat transfer.