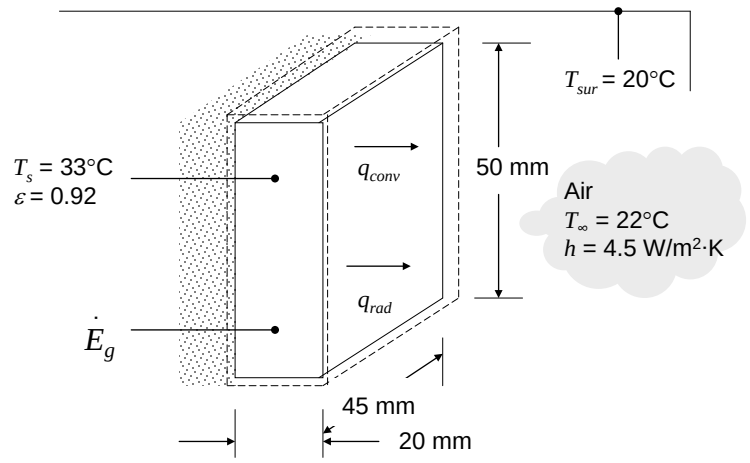
PROBLEM 1.49

KNOWN: Dimensions and emissivity of a cell phone charger. Surface temperature when plugged in. Temperature of air and surroundings. Convection heat transfer coefficient. Cost of electricity.

FIND: Daily cost of leaving the charger plugged in when not in use.

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions, (2) Convection and radiation are from five exposed surfaces of charger, (3) Large surroundings, (4) Negligible heat transfer from back of charger to wall and outlet.

ANALYSIS: At steady-state, an energy balance on the charger gives $\dot{E}_{\text{in}} + \dot{E}_g = 0$, where $\dot{E}_g$ represents the conversion from electrical to thermal energy. The exposed area is A = (50 mm × 45 mm) + 2(50 mm × 20 mm) + 2(45 mm × 20 mm) = 6050 mm^2. Thus,

$$\dot{E}_g = (q_{\text{conv}} + q_{\text{rad}}) = hA(T_s - T_\infty) + \varepsilon\sigma A(T_s^4 - T_{\text{sur}}^4)$$

$$= \left[4.5\ \text{W/m}^2\cdot\text{K}(33°\text{C} - 22°\text{C}) + 0.92 \times 5.67 \times 10^{-8}\ \text{W/m}^2\cdot\text{K}^4 \left((306\ \text{K})^4 - (293\ \text{K})^4 \right) \right] \times 6050 \times 10^{-6}\ \text{m}^2$$

$$= 0.74\ \text{W}$$

This is the total rate of electricity used while the charger is plugged in. The daily cost of electricity is

Cost = 0.74 W × \$0.18/kW·h × 1 kW/1000 W × 24 h/day = \$0.0032/day <

COMMENTS: (1) The radiation and convection heat fluxes are 73 W/m^2 and 50 W/m^2, respectively. Therefore, both modes of heat transfer are important. (2) The cost of leaving the charger plugged in when not in use is small.