HQ 03a solution

A 10x10x10 cm tungsten-walled vacuum box furnace is to be used to heat ceramic samples by supplying 1,800 Watts of electric power to its interior. Heat shields of Ta will be placed around its outside to reduce heat loss.

a) How many heat shields will be needed to allow the furnace to operate at 1600 °C? Assume the heat shields are so close to the tungsten walls that there are no edge effects. Assume that the emissivity of all surfaces is 0.65.

b) How much power would be required to operate at 1500 °C with the correct number of heat shields installed?



Heat Shields replicated on all sides, top, and bottom
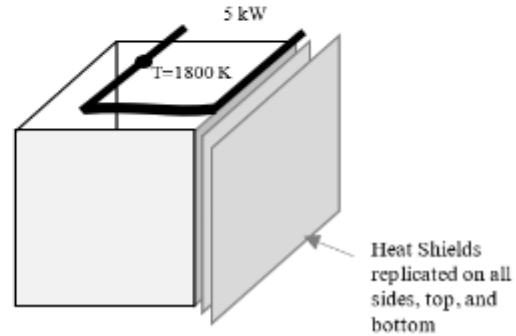
$$L := 0.1 \cdot m \qquad A := 6 \cdot L^2 = 0.06 \ m^2 \qquad\qquad \varepsilon_1 := 0.65 \quad \varepsilon_2 := 0.65$$

$$Q := 1800 \cdot W \qquad qmax := \frac{Q}{A} = \left(3 \cdot 10^4\right) \ \frac{W}{m^2} \qquad\qquad \sigma = \left(5.67 \cdot 10^{-8}\right) \ \frac{W}{m^2 \cdot K^4}$$

a) $\quad T_i := (1600 + 273) \cdot K = \left(1.873 \cdot 10^3\right) \ K \quad T_{Surr} := 300 \cdot K \qquad no := 10$

$$q(n) := \frac{\sigma \cdot \left(T_i^4 - T_{Surr}^4\right)}{\left(\dfrac{1}{\varepsilon_1} + \dfrac{1}{\varepsilon_2} - 1\right) \cdot (n+1)} - qmax$$

Ans $\qquad \mathrm{trunc}\left(\mathrm{root}\left(q(no), no, 1, 20\right) + 1\right) = 11$

b) $\quad T_i := (1500 + 273) \cdot K = \left(1.773 \cdot 10^3\right) \ K$

$$P := A \cdot \frac{\sigma \cdot \left(T_i^4 - T_{Surr}^4\right)}{\left(\dfrac{1}{\varepsilon_1} + \dfrac{1}{\varepsilon_2} - 1\right) \cdot (n+1)} = \left(1.348 \cdot 10^3\right) \ W$$