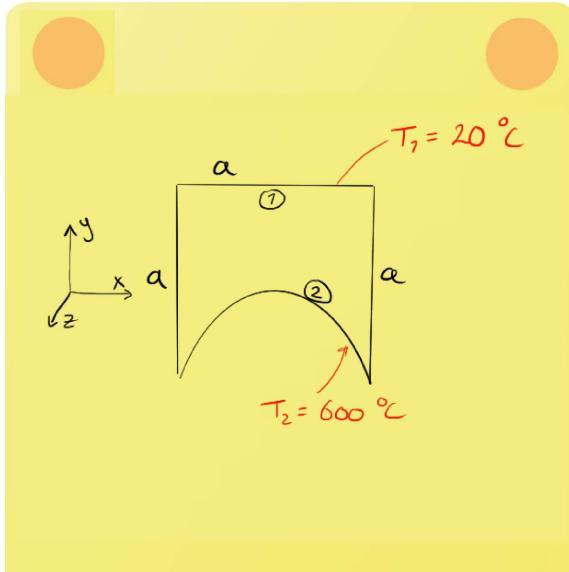


Exam Preparation - Radiation 3



Consider a rectangular duct of cross section $a \times a$ and length L . Inside the duct at the bottom surface a semi-circular pipe is located with radius $a/2$ and also with length L . Consider the enclosure formed by these two surfaces. Edge effects may be neglected. The temperature of the part of the rectangular duct indicated as surface 1 is $T_1 = 20^\circ\text{C}$. The temperature of the surface of the semi-circular pipe indicated with surface 2 is $T_2 = 600^\circ\text{C}$. Assume the surfaces to be black-body surfaces.

- (a) Determine the viewfactor from the rectangular duct surface 1 onto itself Φ_{11} .
- (b) Determine the net rate of heat transfer per unit length \dot{Q}_{21}/L , assuming $a = 1 \text{ m}$.

Black body radiation!

- (a) View factor from 1 to 1 ($\Phi_{3 \rightarrow 1}$)

$$T_1 = 20^\circ\text{C} = 293 \text{ K}$$

$$T_2 = 600^\circ\text{C}$$

$$A_1 = 3aL$$

$$A_2 = \frac{\pi}{2}aL$$

$$\text{Viewfactor: } \Phi_{2 \rightarrow 1} = 1 \quad \text{Reciprocity: } A_1 \Phi_{1 \rightarrow 2} = A_2 \Phi_{2 \rightarrow 1}$$

$$\Phi_{1 \rightarrow 2} = \left(\frac{A_2}{A_1}\right) \Phi_{2 \rightarrow 1} = \frac{\pi a L}{2 \cdot 3aL} = \frac{\pi}{6}$$

$$\text{Summation Rule: } \Phi_{1 \rightarrow 1} + \Phi_{1 \rightarrow 2} = 1 \Rightarrow \Phi_{1 \rightarrow 1} = 1$$

$$- \Phi_{1 \rightarrow 2}$$

$$\Phi_{1 \rightarrow 1} = 1 - \frac{\pi}{6} = 0.476$$



- (b) Net rate of heat transfer per unit length \dot{Q}_{21}/L ,

$$\text{assuming } a = 1 \text{ m}$$

$$\dot{Q}_{2 \rightarrow 1} = A_2 \Phi_{2 \rightarrow 1} \sigma (T_2^4 - T_1^4) = \frac{\pi}{2}aL \cdot 1 (5.67 \cdot 10^{-8}) (873^4 - 273^4)$$

$$\frac{\dot{Q}_{2 \rightarrow 1}}{L} = \frac{\pi}{2}aL \cdot 1 (5.67 \cdot 10^{-8}) (873^4 - 273^4) = 51.08 \text{ kW/m}$$