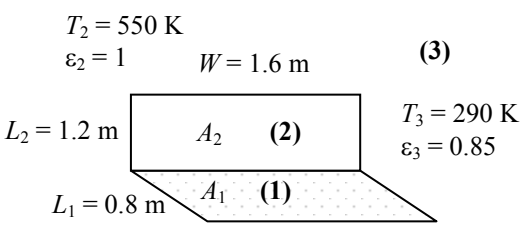
15-86 Two perpendicular rectangular surfaces with a common edge are maintained at specified temperatures. The net rate of radiation heat transfers between the two surfaces and between the horizontal surface and the surroundings are to be determined.

Assumptions **1** Steady operating conditions exist **2** The surfaces are opaque, diffuse, and gray. **3** Convection heat transfer is not considered.

Properties The emissivities of the horizontal rectangle and the surroundings are ε = 0.75 and ε = 0.85, respectively.

Analysis We consider the horizontal rectangle to be surface 1, the vertical rectangle to be surface 2 and the surroundings to be surface 3. This system can be considered to be a three-surface enclosure. The view factor from surface 1 to surface 2 is determined from

$$\left.\begin{aligned}\frac{L_1}{W}&=\frac{0.8}{1.6}=0.5\\ \frac{L_2}{W}&=\frac{1.2}{1.6}=0.75\end{aligned}\right\}F_{12}=0.27 \quad \text{(Fig. 15-6)}$$



The surface areas are

$$A_1 = (0.8\text{ m})(1.6\text{ m}) = 1.28\text{ m}^2$$

$$A_2 = (1.2\text{ m})(1.6\text{ m}) = 1.92\text{ m}^2$$

$$A_3 = 2\times\frac{1.2\times 0.8}{2}+\sqrt{0.8^2+1.2^2}\times 1.6 = 3.268\text{ m}^2$$

Note that the surface area of the surroundings is determined assuming that surroundings forms flat surfaces at all openings to form an enclosure. Then other view factors are determined to be

$$A_1F_{12} = A_2F_{21} \longrightarrow (1.28)(0.27) = (1.92)F_{21} \longrightarrow F_{21} = 0.18 \qquad \text{(reciprocity rule)}$$

$$F_{11}+F_{12}+F_{13} = 1 \longrightarrow 0+0.27+F_{13} = 1 \longrightarrow F_{13} = 0.73 \qquad \text{(summation rule)}$$

$$F_{21}+F_{22}+F_{23} = 1 \longrightarrow 0.18+0+F_{23} = 1 \longrightarrow F_{23} = 0.82 \qquad \text{(summation rule)}$$

$$A_1F_{13} = A_3F_{31} \longrightarrow (1.28)(0.73) = (3.268)F_{31} \longrightarrow F_{31} = 0.29 \qquad \text{(reciprocity rule)}$$

$$A_2F_{23} = A_3F_{32} \longrightarrow (1.92)(0.82) = (3.268)F_{32} \longrightarrow F_{32} = 0.48 \qquad \text{(reciprocity rule)}$$

We now apply Eq. 15-35b to each surface to determine the radiosities.

Surface 1:

$$\sigma T_1^{\,4} = J_1 + \frac{1-\varepsilon_1}{\varepsilon_1}\left[F_{12}(J_1-J_2)+F_{13}(J_1-J_3)\right]$$

$$(5.67\times 10^{-8}\text{ W/m}^2.\text{K}^4)(400\text{ K})^4 = J_1 + \frac{1-0.75}{0.75}\left[0.27(J_1-J_2)+0.73(J_1-J_3)\right]$$

Surface 2:

$$\sigma T_2^{\,4} = J_2 \longrightarrow (5.67\times 10^{-8}\text{ W/m}^2.\text{K}^4)(550\text{ K})^4 = J_2$$

Surface 3:

$$\sigma T_3^{\,4} = J_3 + \frac{1-\varepsilon_3}{\varepsilon_3}\left[F_{31}(J_3-J_1)+F_{32}(J_3-J_2)\right]$$

$$(5.67\times 10^{-8}\text{ W/m}^2.\text{K}^4)(290\text{ K})^4 = J_3 + \frac{1-0.85}{0.85}\left[0.29(J_3-J_1)+0.48(J_3-J_2)\right]$$

Solving the above equations, we find

$$J_1 = 1587\text{ W/m}^2,\quad J_2 = 5188\text{ W/m}^2,\quad J_3 = 811.5\text{ W/m}^2$$

Then the net rate of radiation heat transfers between the two surfaces and between the horizontal surface and the surroundings are determined to be

$$\dot{Q}_{21} = -\dot{Q}_{12} = -A_1F_{12}(J_1-J_2) = -(1.28\text{ m}^2)(0.27)(1587-5188)\text{W/m}^2 = \mathbf{1245\text{ W}}$$

$$\dot{Q}_{13} = A_1F_{13}(J_1-J_3) = (1.28\text{ m}^2)(0.73)(1587-811.5)\text{W/m}^2 = \mathbf{725\text{ W}}$$

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