

Given:

Consider steady heat transfer through a 5 m by 7 m brick wall with a thickness of 30 cm. On one side of the wall, the room temperature of a house is 27°C; the outside temperature on the other side is 0°C. The temperature of the inner and outer surfaces are 20°C and 5°C, respectively, and the rate of heat transfer is measured to be 1035 W.

$$h := 5\text{ m} \quad w := 7\text{ m} \quad t := 30\text{ cm}$$

$$T_{\text{room}} := 27^\circ\text{C} \quad T_{\text{outside}} := 0^\circ\text{C}$$

$$T_{\text{inner}} := 20^\circ\text{C} \quad T_{\text{outer}} := 5^\circ\text{C} \quad \dot{Q}' := 1035\text{ W}$$

Required:

Determine the rate of entropy generation in the wall and the rate of total entropy generation associated with the heat transfer process.

Solution:

Starting with an entropy balance with no mass transfer shows

$$\frac{d}{dt}S_{\text{sys}} = \sum S'_{\text{in}} - \sum S'_{\text{out}} + S'_{\text{gen}}$$

$$0 = \sum S'_{\text{in}} - \sum S'_{\text{out}} + S'_{\text{gen}}$$

$$S'_{\text{gen}} = \sum S'_{\text{out}} - \sum S'_{\text{in}}$$

The entropy rate in and out are determined by the heat transfer at the particular boundaries so

$$S'_{\text{gen}} := \frac{\dot{Q}'}{T_{\text{outer}}} - \frac{\dot{Q}'}{T_{\text{inner}}} = 0.1904 \cdot \frac{\text{W}}{\text{K}}$$

To determine the rate of entropy generation for the entire process, the process can be repeated but with a change of boundaries. Starting with an entropy balance with no mass transfer shows

$$\frac{d}{dt}S_{\text{sys}} = \sum S'_{\text{in}} - \sum S'_{\text{out}} + S'_{\text{gen}}$$

$$0 = \sum S'_{\text{in}} - \sum S'_{\text{out}} + S'_{\text{gen}}$$

$$S'_{\text{gen}} = \sum S'_{\text{out}} - \sum S'_{\text{in}}$$

The entropy rate in and out are determined by the heat transfer at the particular boundaries so

$$S'_{\text{gen}} := \frac{\dot{Q}'}{T_{\text{outside}}} - \frac{\dot{Q}'}{T_{\text{room}}} = 0.3409 \cdot \frac{\text{W}}{\text{K}}$$

