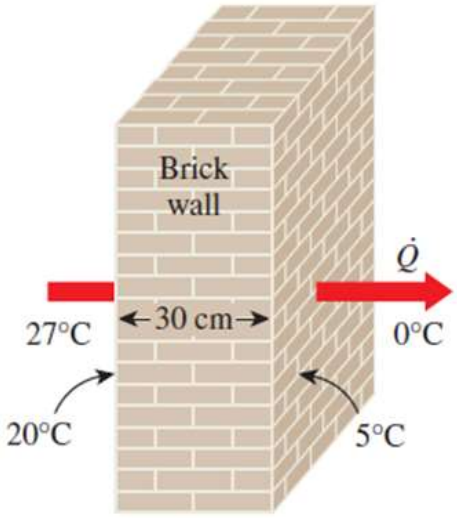
Given:

Consider steady heat transfer through a 5 m by 7 m brick wall with a thickness of 30 cm. On on 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.

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

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

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



Required:

Deteremine 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

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

$$0 = \Sigma \dot{S}'_{in} - \Sigma \dot{S}'_{out} + \dot{S}'_{gen}$$

$$\dot{S}'_{gen} = \Sigma \dot{S}'_{out} - \Sigma \dot{S}'_{in}$$

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

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

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

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

$$0 = \Sigma \dot{S}'_{in} - \Sigma \dot{S}'_{out} + \dot{S}'_{gen}$$

$$\dot{S}'_{gen} = \Sigma \dot{S}'_{out} - \Sigma \dot{S}'_{in}$$

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

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