Given:

The temperature distribution across a wall 1 m thick at a certain instant of time is given as

$$T(x) = a + b \cdot x + c \cdot x^2$$

where T is in degrees Celsius and x is in meters, while a, b, and c are listed below. The wall has an area of 10 m^2 and a thermal conductivity of 40 W/mK.

$$a := 900\Delta°C \qquad b := -300\frac{\Delta°C}{m} \qquad c := -50\frac{\Delta°C}{m^2}$$

Required:

Determine the rate of heat transfer entering the wall and leaving the wall. Is the wall gaining or losing energy?

Solution:

The wall thickness, area, and thermal conductivity is defined as

$$L := 1m \qquad A_w := 10m^2 \qquad k_t := 40\frac{W}{m \cdot K}$$

The temperature distribution is defined as

$$T(x) := a + b \cdot x + c \cdot x^2$$

The rate of heat transfer as a function of position within the wall is then

$$Q'(x) := -k_t \cdot A_w \cdot \frac{d}{dx}T(x) \qquad \frac{d}{dx}T(x) \rightarrow -\frac{300 \cdot \Delta°C}{m} - \frac{100 \cdot \Delta°C \cdot x}{m^2}$$

The rate of heat transfer entering the wall is then

$$\boxed{Q'_{in} := Q'(0m) = 120 \cdot kW}$$

The rate of heat transfer leaving the wall is then

$$\boxed{Q'_{out} := Q'(L) = 160 \cdot kW}$$

Since $Q'_{out} > Q'_{in}$, the wall is losing energy.