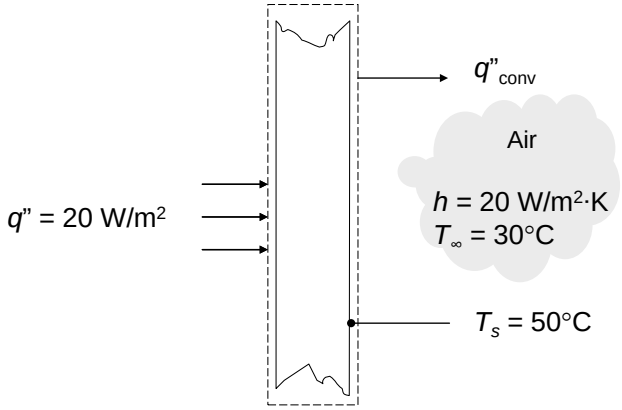
PROBLEM 1.9

KNOWN: Heat flux at one face and air temperature and convection coefficient at other face of plane wall. Temperature of surface exposed to convection.

FIND: If steady-state conditions exist. If not, whether the temperature is increasing or decreasing.

SCHEMATIC:



ASSUMPTIONS: (1) One-dimensional conduction, (2) No internal energy generation.

ANALYSIS: Conservation of energy for a control volume around the wall gives

$$\frac{dE_{st}}{dt} = \dot{E}_{in} - \dot{E}_{out} + \dot{E}_g$$

$$\frac{dE_{st}}{dt} = q''_{in}A - hA(T_s - T_\infty) = \left[q''_{in} - h(T_s - T_\infty)\right]A$$

$$= \left[20\ \text{W/m}^2 - 20\ \text{W/m}^2 \cdot \text{K}(50°\text{C} - 30°\text{C})\right]A = -380\ \text{W/m}^2 A$$

Since $dE_{st}/dt \neq 0$, the system is not at steady-state. <

Since $dE_{st}/dt < 0$, the stored energy is decreasing, therefore the wall temperature is decreasing. <

COMMENTS: When the surface temperature of the face exposed to convection cools to 31°C, $q_{in} = q_{out}$ and $dE_{st}/dt = 0$ and the wall will have reached steady-state conditions.