10-49 A thin copper plate is sandwiched between two epoxy boards. The error involved in the total thermal resistance of the plate if the thermal contact conductances are ignored is to be determined.

Assumptions **1** Steady operating conditions exist. **2** Heat transfer is one-dimensional since the plate is large. **3** Thermal conductivities are constant.

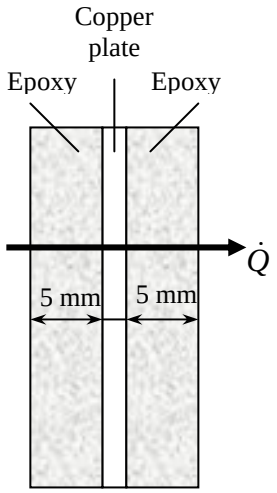
Properties The thermal conductivities are given to be k = 386 W/m·°C for copper plates and k = 0.26 W/m·°C for epoxy boards. The contact conductance at the interface of copper-epoxy layers is given to be h_c = 6000 W/m^2·°C.

Analysis The thermal resistances of different layers for unit surface area of 1 m^2 are

$$R_{\text{contact}} = \frac{1}{h_c A_c} = \frac{1}{(6000\ \text{W/m}^2\cdot\text{°C})(1\ \text{m}^2)} = 0.00017\ \text{°C/W}$$

$$R_{\text{plate}} = \frac{L}{kA} = \frac{0.001\ \text{m}}{(386\ \text{W/m}\cdot\text{°C})(1\ \text{m}^2)} = 2.6\times10^{-6}\ \text{°C/W}$$

$$R_{\text{epoxy}} = \frac{L}{kA} = \frac{0.005\ \text{m}}{(0.26\ \text{W/m}\cdot\text{°C})(1\ \text{m}^2)} = 0.01923\ \text{°C/W}$$



The total thermal resistance is

$$R_{\text{total}} = 2R_{\text{contact}} + R_{\text{plate}} + 2R_{\text{epoxy}}$$
$$= 2\times0.00017 + 2.6\times10^{-6} + 2\times0.01923 = 0.03880\ \text{°C/W}$$

Then the percent error involved in the total thermal resistance of the plate if the thermal contact resistances are ignored is determined to be

$$\%\text{Error} = \frac{2R_{\text{contact}}}{R_{\text{total}}}\times100 = \frac{2\times0.00017}{0.03880}\times100 = \mathbf{0.88\%}$$

which is negligible.