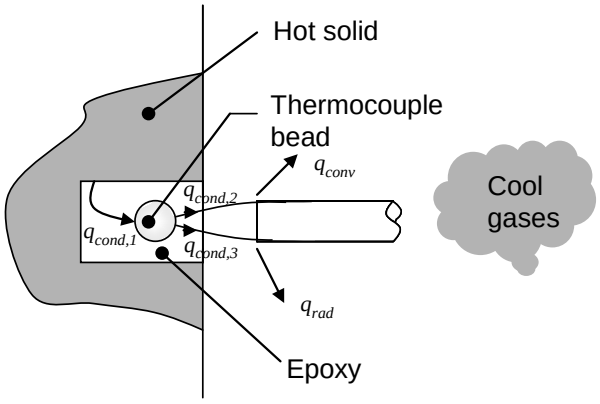
PROBLEM 1.62(g)

KNOWN: Thermocouple junction held in small hole in solid material by epoxy. Solid is hotter than surroundings.

FIND: Identify heat transfer processes. Will thermocouple junction sense temperature less than, equal to, or greater than solid temperature? How will thermal conductivity of epoxy affect junction temperature?

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions.

ANALYSIS: Heat is transferred from the solid material through the epoxy to the thermocouple junction by conduction, $q_{\text{cond},1}$. Heat is also transferred from the junction along the thermocouple wires and their sheathing by conduction ($q_{\text{cond},2}$ and $q_{\text{cond},3}$), and from there to the surroundings by convection (q_{conv}) and radiation (q_{rad}). Thus, the junction is heated by the solid and cooled by the surroundings, and its temperature will be between the solid temperature and the temperature of the cool gases.

The junction temperature will be less than the solid temperature. <

Under steady-state conditions, the rate at which heat is transferred to the junction from the solid material must equal the rate at which heat is transferred from the junction to the cool gases and surroundings. If we think of this heat transfer rate as fixed, then Equation 1.2 shows that a higher thermal conductivity for the epoxy will result in a smaller temperature difference across the epoxy. This leads to the thermocouple sensing a temperature that is closer to the solid temperature.

Higher thermal conductivity of epoxy leads to the thermocouple temperature being closer to the solid temperature. <

COMMENTS: (1) High thermal conductivity epoxies are formulated specifically for the purpose of affixing thermocouples. Their thermal conductivity is increased by adding small particles of high thermal conductivity materials such as silver. (2) Different types of thermocouple wires are available. To further reduce temperature differences between the solid and the thermocouple junction, small diameter thermocouple wires of relatively low thermal conductivity, such as chromel and alumel, are preferred. (3) Because thermocouple wires are made of different metals, in general $q_{\text{cond},2} \neq q_{\text{cond},3}$.