Heat generation in an electrical wire

An electrical wire extends across a room that is maintained at T_a. Heat is generated in the wire as a result of resistance heating and the surface temperature of the wire is measured to be T_s. Determine the convection heat transfer coefficient for heat transfer between the outer surface of the wire and the room.

Hints

- Assume steady-state heat transfer.
- Radiation can be neglected.

Given parameter

- Length of the wire: $L = 2.1$ m
- Diameter of the wire: $d = 0.2$ cm
- Room temperature: $T_a = 20$ °C
- Surface temperature of the wire: $T_s = 180$ °C
- Voltage drop: $V = 110$ V
- Electric current through the wire: $I = 3$ A

Resistance wire

A long homogeneous resistance wire is being used to heat the air in a room by the passage of electric current. Heat is generated in the wire uniformly at a constant rate $\dot{\Phi}'''$ as a result of resistance heating. If the temperature of the outer surface of the wire remains constant at T_s, determine the temperature at $r = 3.5$ mm after steady operation conditions are reached.

Hints

- Radiation can be neglected.

Given parameter

- Outer radius of the wire: $r_0 = 5$ mm
- Heat generation in the wire: $\dot{\Phi}''' = 5 \cdot 10^7$ W/m^3
- Temperature of the outer surface of the wire: $T_s = 180$ °C
- Thermal conductivity of the wire: $\lambda = 6$ W/mK

Transistors

Four power transistors, each dissipating $\dot{\Phi}$, are mounted on a thin plate. The heat generated by the transistors is to be dissipated by both surfaces of the plate to the surrounding flowing air at temperature T_a. Determine the temperature T_s of the plate.

Hints

- The entire plate can be assumed to be isothermal.
- The exposed surface area of the transistor can be taken to be equal to its base area.
- Radiation can be neglected.

Given parameter

- Surface area of a side plane: $A_\mathrm{s} = 24$ cm x 24 cm
- Heat generated by a transistor: $\dot{\Phi} = 15$ W
- Average convection heat transfer coefficient $\alpha = 25$ W/m^{2}K
- Ambient temperature: $T_\mathrm{a} = 18$ °C