task_rj0r6j4apumukrj6_with_calculation

Student Group

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resistivity, power

Excercise: Temperature-dependent resistance of a wire (written test, approx. 6% of a 60-minute written test, WS2022)

A heating element made of a Nichrome wire with a round cross-section is used in an electric oven. Nichrome is a common Nickel Chromium alloy for heating elements.
The Nichrome wire has a resistivity of $1.10\cdot 10^{-6} \Omega m$.
The heating element is $3 m$ long and has a diameter of $3.57 mm$.

1. Calculate the resistance R of the heating element.

Solution

\begin{align*} R &= \rho \cdot \frac{l}{A} && | \text{with } A = r^2 \cdot \pi = \frac{1}{4} d^2 \cdot \pi \\ R &= \rho \cdot \frac{4 \cdot l}{d^2 \cdot \pi} && \\ R &= 1.10\cdot 10^{-6} \Omega m \cdot \frac{4 \cdot 3m}{(3.57\cdot 10^{-3}m)^2 \cdot \pi} && \\ \end{align*}

Final result

\begin{align*} R &= 0.33 \Omega \\ \end{align*}

2. The heating element is used to heat the oven to a temperature of 180°C. For this, a power dissipation (= heat flow) of P=40 W is necessary.
Calculate the current I needed to operate it.

Solution

\begin{align*} P = U \cdot I = R \cdot I^2 \quad \rightarrow \quad I= \sqrt{\frac{P}{R}} = \sqrt{\frac{40 W}{0.33 \Omega}} \end{align*}

Final result

\begin{align*} I = 11 A \end{align*}