

task_rj0r6j4apumukrj6_with_calculation

Student Group

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Exercise: 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 $1.10 \cdot 10^{-6} \text{ } \Omega \text{ m}$.

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

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

Final result

$$R = 0.33 \text{ } \Omega$$

2. The heating element is used to heat the oven to a temperature of 180°C. For this, a power dissipation (= heat flow) of $P=40 \text{ W}$ is necessary.

Calculate the current I needed to operate it.

Solution

$$P = U \cdot I = R \cdot I^2 \quad \rightarrow \quad I = \sqrt{\frac{P}{R}} = \sqrt{\frac{40 \text{ W}}{0.33 \text{ } \Omega}}$$

Final result

$$I = 11 \text{ A}$$

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Last update: 2023/02/11 22:24

