

task_rj0r6j4apumukrj6_with_calculation

Student Group

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resistivity, power, exam ee1 WS2022

Exercise 1.1 : Resistance of a Wire by Resistivity

(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 $1.10 \cdot 10^{-6} \, \Omega \cdot \text{m}$.

The heating element is $3 \, \text{m}$ long and has a diameter of $3.57 \, \text{mm}$.

1. Calculate the resistance R of the heating element.

Solution

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

Final result

$$R = 0.33 \, \Omega$$

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

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

Final result

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