task_rj0r6j4apumukrj6_with_calculation

Student Group

First Name	Surname	Matrikel Nr.

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resistivity, power, exam ee1 WS2022

Exercise E1.1 Resistance of a Wire by Resistivity
(written test, approx. 6 % of a 60-minute written test, WS2022)

A heating element is made of Nichrome wire with a round cross-section ($d=0.5 ~\rm{mm}$). For a specific application a power dissipation (= heat flow) of $P=40 ~\rm{W}$ is necessary.
Calculate the current I needed to operate the heating element.
Nichrome is a common Nickel-Chromium alloy for heating elements.
The Nichrome wire has a resistivity of $1.10\cdot 10^{-6} ~\Omega \rm{m}$.
The heating element is $3 ~\rm{m}$ long and has a diameter of $3.57 ~\rm{mm}$.

Solution

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

1. Calculate the resistance R of the heating element.

Solution

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

\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 \rm{m} \cdot \frac{4 \cdot 3~\rm{m}}{(3.57\cdot 10^{-3}~\rm{m})^2 \cdot \pi} && \\ \end{align*}