

aufgabe_1.7.6_mit_rechnung

Student Group

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Exercise 1.6.6: Temperature-dependent resistance of a winding (written test, approx. 6 % of a 60-minute written test, WS2020)

On the rotor of an asynchronous motor, the windings are designed in copper. The length of the winding wire is $40\text{~}\text{m}$. The diameter is $0.4\text{~}\text{mm}$. When the motor is started, it is uniformly cooled down to the ambient temperature of $20\text{~}^\circ\text{C}$. During operation the windings on the rotor have a temperature of $90\text{~}^\circ\text{C}$.

$$\alpha_{\text{Cu},20\text{~}^\circ\text{C}} = 0.0039 \text{~}\frac{1}{\text{K}}$$

$$\beta_{\text{Cu},20\text{~}^\circ\text{C}} = 0.6 \cdot 10^{-6} \text{~}\frac{1}{\text{K}^2}$$

$$\rho_{\text{Cu},20\text{~}^\circ\text{C}} = 0.0178 \text{~}\frac{\Omega \text{~}\text{mm}^2}{\text{m}}$$

Use both the linear and quadratic temperature coefficients! 1. determine the resistance of the wire for $T = 20\text{~}^\circ\text{C}$.

Solution

$$\begin{aligned} R_{20\text{~}^\circ\text{C}} &= \rho_{\text{Cu},20\text{~}^\circ\text{C}} \cdot \frac{l}{A} \quad | \text{with} \\ A &= r^2 \cdot \pi = \frac{1}{4} d^2 \cdot \pi \quad || R_{20\text{~}^\circ\text{C}} = \\ \rho_{\text{Cu},20\text{~}^\circ\text{C}} \cdot \frac{4 \cdot l}{d^2 \cdot \pi} \quad || R_{20\text{~}^\circ\text{C}} &= \\ 0.0178 \text{~}\frac{\Omega \text{~}\text{mm}^2}{\text{m}} \cdot \frac{4 \cdot 40\text{~}\text{m}}{(0.4\text{~}\text{mm})^2 \cdot \pi} \quad || \end{aligned}$$

Final result

$$R_{20\text{~}^\circ\text{C}} = 5.666 \text{~}\Omega \rightarrow 5.7 \text{~}\Omega$$

2. what is the increase in resistance ΔR between $20\text{~}^\circ\text{C}$ and $90\text{~}^\circ\text{C}$ for one winding?

Solution

$$\begin{aligned} R_{90\text{~}^\circ\text{C}} &= R_{20\text{~}^\circ\text{C}} \cdot (1 + \alpha_{\text{Cu},20\text{~}^\circ\text{C}} \cdot \Delta T + \beta_{\text{Cu},20\text{~}^\circ\text{C}} \cdot \Delta T^2) \quad | \text{with } \Delta T = T_2 - T_1 = \\ 90\text{~}^\circ\text{C} - 20\text{~}^\circ\text{C} &= 70\text{~}^\circ\text{C} = 70\text{~}\text{K} \quad || \Delta R = R_{20\text{~}^\circ\text{C}} \cdot (\\ \alpha_{\text{Cu},20\text{~}^\circ\text{C}} \cdot \Delta T + \beta_{\text{Cu},20\text{~}^\circ\text{C}} \cdot \Delta T^2) \quad || \Delta R &= \\ 5.666 \text{~}\Omega \cdot (0.0039 \text{~}\frac{1}{\text{K}} \cdot 70\text{~}\text{K} + 0.6 \cdot 10^{-6} \cdot \frac{1}{\text{K}^2} \cdot (70\text{~}\text{K})^2) \quad || \end{aligned}$$

Final result

$$\Delta R = 1.56 \text{~}\Omega \rightarrow 1.6 \text{~}\Omega$$

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