

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~m . The diameter is 0.4~mm . When the motor is started, it is uniformly cooled down to the ambient temperature of 20°C . During operation the windings on the rotor have a temperature of 90°C .

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

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

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

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

Solution

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

Final result

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

2. what is the increase in resistance ΔR between 20°C and 90°C for one winding?

Solution

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

Final result

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

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Last update: 2023/03/10 18:19

