

# 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  $40\text{ m}$ . The diameter is  $0.4\text{ mm}$ . When the motor is started, it is uniformly cooled down to the ambient temperature of  $20^\circ\text{C}$ . During operation the windings on the rotor have a temperature of  $90^\circ\text{C}$ .

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

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

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

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

Solution

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

Final result

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

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

Solution

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

Final result

$$\Delta R = 1.56 \Omega \rightarrow 1.6 \Omega$$

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