aufgabe_1.7.6_mit_rechnung

Student Group

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Excercise 1.7.6: 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.
$\alpha_{Cu,20°C}=0.0039 \frac{1}{K}$
$\beta_{Cu,20°C}=0.6 \cdot 10^{-6} \frac{1}{K^2}$
$\rho_{Cu,20°C}=0.0178 \frac{\Omega mm^2}{m}$

Use both the linear and quadratic temperature coefficients! 1. determine the resistance of the wire for $T = 20°C$.

Solution

\begin{align*} R_{20°C} &= \rho_{Cu,20°C} \cdot \frac{l}{A} && | \text{with } A = r^2 \cdot \pi = \frac{1}{4} d^2 \cdot \pi \\ R_{20°C} &= \rho_{Cu,20°C} \cdot \frac{4 \cdot l}{d^2 \cdot \pi} && \\ R_{20°C} &= 0.0178 \frac{\Omega mm^2}{m} \cdot \frac{4 \cdot 40m}{(0,4mm)^2 \cdot \pi} && \\ \end{align*}

Final result

\begin{align*} R_{20°C} &= 5.666 \Omega \rightarrow 5.7 \Omega \\ \end{align*}

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

Solution

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

Final result

\begin{align*} \Delta R &= 1.56 \Omega \rightarrow 1.6 \Omega \\ \end{align*}

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