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 $40~\rm{m}$. The diameter is $0.4~\rm{mm}$. When the motor is started, it is uniformly cooled down to the ambient temperature of $20~°\rm{C}$. During operation the windings on the rotor have a temperature of $90~°\rm{C}$.
$\alpha_{Cu,20~°\rm{C}}=0.0039 ~\frac{1}{\rm{K}}$
$ \beta_{Cu,20~°\rm{C}}=0.6 \cdot 10^{-6} ~\frac{1}{\rm{K}^2}$
$ \rho_{Cu,20~°\rm{C}}=0.0178 ~\frac{\Omega \rm{mm}^2}{\rm{m}}$

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

Solution

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

Final result

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

Final result

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