# 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 $90°C$.
$\alpha_{Cu,20°C}=0.0039 ~\frac{1}{K}$
$\beta_{Cu,20°C}=0.6 \cdot 10^{-6} ~\frac{1}{K^2}$
$\rho_{Cu,20°C}=0.0178 ~\frac{\Omega mm^2}{m}$

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

Solution

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

Final result

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

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

Solution

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

Final result

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