task_70jjg4yzznocarsq_with_calculation

Student Group

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Exercise E1.1 Temperature-dependent Resistance
(written test, approx. 6 % of a 60-minute written test, WS2022)

A refrigeration system has a temperature sensor with a temperature-dependent resistor. The thermistor has a resistance of $10 ~\rm{k}\Omega$ at $25 ~°\rm{C}$.
Its temperature coefficients are: $\alpha=0.01 ~{{1}\over{\rm{K}}}$ and $\beta=71 \cdot 10^{-6}~{{1}\over{\rm{K}^2}}$
The temperature inside the refrigeration system can reach down to $-40 ~°\rm{C}$.

1. Calculate the resistance of the thermistor at $-40 ~°\rm{C}$.
2. Explain, why a temperature sensor with a negative temperature coefficient is used in refrigeration systems.

Result

1. $R = 6.5 ~\rm{k}\Omega$
2. The power of the resistor $P=U\cdot I = R\cdot I^2 = {U^2}\over{R}$ is inversely proportional to the resistance. Therefore, a resistor with a negative temperature coefficient has a lower resistance at low temperatures and thus a higher heat flow up the refrigeration system.

Solution

1. Calculate the resistance of the thermistor at $-40 ~°\rm{C}$.

   The power of the resistor $P=U\cdot I = R\cdot I^2 = {U^2}\over{R}$ is inversely proportional to the resistance. Therefore, a resistor with a negative temperature coefficient has a lower resistance at low temperatures and thus a higher heat flow up the refrigeration system.

   Therefore, with constant U and increasing R the power decreases. Ten times more resistance decreases the heat flow to one-tenth.

   \begin{align*} R &= R_0 \cdot (1 + \alpha \cdot \Delta T + \beta \cdot \Delta T^2) && | \text{with } \Delta T = T_{\rm end} - T_{\rm start}\\ R &= 10 ~\rm{k}\Omega \cdot \left(1 + 0.01 ~{{1}\over{\rm{K}}} \cdot (-40~°\rm{C} - 25~°\rm{C}) + 71 \cdot 10^{-6}~{{1}\over{\rm{K}^2}} \cdot (-40~°\rm{C} - 25~°\rm{C})^2 \right) \\ \end{align*}