The hot electronics box

QUESTION: A closed electronics box is mounted on one of our machines as shown in the figure. The box's outer dimensions are 70x150x200 mm^3 and the wall material is aluminium. The heat production in the box is 40 W and we have measured the box's temperature to be 60 °C when the temperature in our workshop is 18 °C. We will be replacing the electronics, and the heat production will then increase to about 50 W. Is it possible to calculate in advance what temperature the electronics box will have, and is there an easy way to cool it if necessary?

Martin A

ANSWER: In this case the heat flow from the electronics box to the surroundings occurs mainly via natural convection and radiation. Some heat transfer also occurs via thermal conduction to the machine stand via the fastening. Very approximately, the heat flow to the surroundings via convection and radiation can be written

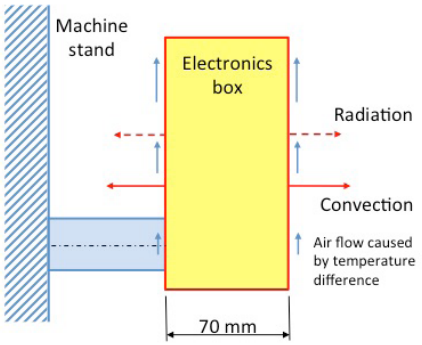
$$Q = h_{tot} A (T_{box} - T_{surr}) \quad (1)$$

where h_{tot} in $W/(m^2K)$ is a total heat transfer coefficient that includes both convection and radiation, A in m^2 is the heat transfer area, T_{box} in °C is the electronics box's outer temperature, and T_{surr} in °C is the ambient temperature. All quantities are mean values. The heat transfer via conduction to the machine stand is not included in the equation (1).

With the given values, h_{tot} becomes approximately 9 $W/(m^2K)$, which in this case is a reasonable value. If we assume that the value is constant, when we increase the heat production to 50 W we find that the temperature increases from 60 °C to just over 70 °C. This estimate is based on many assumptions and approximations but it still gives us some idea of the temperature increase we can expect.

This temperature is so high that you should consider reducing it. In addition, inside the box the temperature of some components will be higher than the box's outer temperature. Even if the electronics can endure the high temperature, they will have a shorter lifespan.

Unfortunately there is no easy way to reduce the temperature of the existing electronics box when the heat production increases. Based on the equation (1) we find that for a specified heat production Q we can reduce the temperature of the electronics box by increasing the heat transferring area A and/or the total heat transfer coefficient h_{tot}. The area can be increased by e.g. equipping the electronics box with fins but this would require replacing the existing box. The heat transfer coefficient can be increased by increasing the air velocity around the box with a fan but this also requires a rebuild.



If the temperature of the machine stand is always lower than that of the electronics box you can increase the heat flow to the stand by reducing the thermal resistance between the box and the stand. Greater heat flow to the stand reduces the box's temperature. This possibility also requires a rebuild. Another possibility you should explore is whether it is possible to reduce the heat production in the electronics box. It may not be necessary for all the electronics to be constantly activated. Some of them may only need to be activated on certain occasions. A lower heat production produces a lower temperature.

Which measure(s) to choose to reduce the temperature of the electronics box depends on the circumstances of each individual case. When doing a rebuild you should also install one or more measuring points inside the electronics box and at least at the box's casing so that you can monitor the temperature.

Questions should be of general interest and be about temperature measurement techniques and/or heat transfer.

QUESTIONS ANSWERS

If you have questions or comments, contact Dan Loyd, LiU, dan.loyd@liu.se