AIR TEMPERATURE INSIDE A HEN SHED

QUESTION ? ANSWER

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

QUESTION: We measure the indoor temperature in a large shed that houses laying hens on one of our experimental farms. To take the measurements, someone has previously installed a type K sheathed thermocouple with a 3 mm diameter. The thermocouple is mounted on an inner wall of the shed and the tip is very close to the wall. Unfortunately the wall sometimes gets extremely dirty and the thermocouple disappears inside the dirt. Is it possible to estimate how the dirt affects the measurement error?

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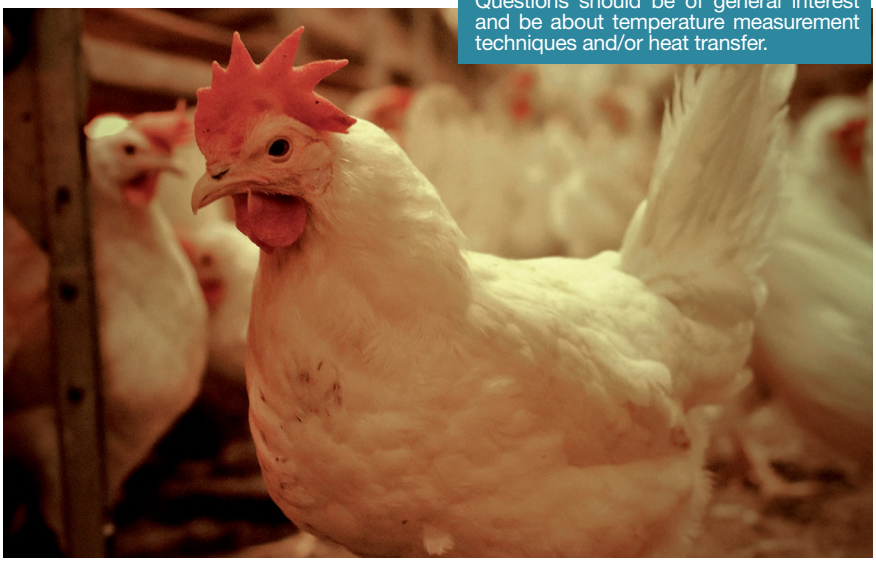

ANSWER: If we start by assuming that the air temperature inside the shed is constant, then both the inner wall and the thermocouple will adopt the air temperature. We then assume that we can disregard any possible effect of radiation from warm or cold surfaces inside the shed. If the thermocouple is calibrated and correctly installed, it will measure the air temperature under stationary conditions. If the thermocouple gets dirty, nothing really happens to the temperature measurement process as long as the temperature inside the shed is constant. The inner wall, the thermocouple, and the dirt will have the same temperature. The measurement error will be the same as for the clean thermocouple.

In contrast, if the air temperature inside the shed is altered, then the response time will be extended when the thermocouple is dirty compared with when it is clean. The dirt acts as insulation, and the heat transfer between the air and the thermocouple is reduced compared with when a clean thermocouple is involved. The reduced heat flow affects the temperature of both the thermocouple and the inner wall, which makes the response time longer. Whether or not the longer response time is acceptable must be determined from case to case. The air temperature inside large sheds normally varies by up to a few degrees, and you should therefore use several temperature sensors so you can determine the average temperature.

In conclusion, under stationary conditions the measurement process is not affected by the presence of dirt. When time-dependent processes are involved, the presence of dirt will extend the response time. If the temperature sensor were to be located on an outer wall of the shed, both the stationary and the non-stationary measurement process can be affected by the presence of dirt. The reason is that the heat transfer through the outer wall lessens when the wall is dirty. This affects the temperature field and thereby the measured temperature – increasing the measurement error.

In the case discussed here, the sensor was a thermocouple inside a hen shed but the conclusions also apply to other types of sensors in totally different environments.

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