MEASURING THE OUTDOOR TEMPERATURE

QUESTION ? ANSWER

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

QUESTION: We measure the outdoor temperature using a sheathed thermocouple with a diameter of 2 mm and the tip is located 20 mm out from the house wall. Will the air velocity have any influence on the measurement result? When the wind blows it feels a lot colder than when the air is still.

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ANSWER: Here we must distinguish between the act of measuring the outdoor temperature using a passive sensor (the thermocouple) and the body's experience of the same temperature.

If we start with the thermocouple, it measures its own temperature and nothing else. The heat exchange with the air occurs via convection. Heat exchange also occurs between the thermocouple and its surroundings via radiation if the thermocouple and its surroundings (the house, ground, sky etc.) have different temperatures. For example, during the cold months of the year, the outer wall of the house has a surface temperature that is slightly higher than the air temperature. A well-insulated house has a lower surface temperature than a poorly insulated house. This also means that some heat transfer can occur from the house to the sensor via conduction in the sheathed thermocouple.

The dominant heat transfer mechanism is convection, and in normal cases the influence of the heat conduction and radiation on the measurement result is very small. The difference between the air temperature and the measured temperature is therefore also very small. If the wind is blowing, the influence of the convection increases and the small temperature deviation that might occur between the air and the sensor becomes even smaller. If you believe that the ambient temperature, e.g. the sky temperature, is deviating from the air temperature, you should first equip the thermocouple with a radiation shield if you want to increase the accuracy. The heat conduction in the thermocouple can be reduced by increasing the distance between the wall and the sensor.

Unlike the thermocouple, the body is an active sensor. Heat is produced in the body and the heat transfer system is complicated. The heat transfer from an unprotected area of skin to colder surroundings occurs via convection and radiation. Corresponding to this heat flow is a heat flow of equal size from inside the body out to the skin's surface, and the heat transfer is controlled by a complex regulating system. When the wind blows, the influence of the convection increases and consequently the heat transfer increases. The air does not become colder when there is a wind, but the increased heat flow makes the body's surface temperature fall and we feel that it has become colder. Moisture transport to and from the body also influences the cooling process and thereby the sensation of cold. Ref 1.

In summary, in normal cases the deviation between the air temperature and the measured temperature is very small. Any deviation caused by radiation and heat conduction is reduced if the wind is blowing.

Ref 1: www.pentronic.se > News > Technical Information > Examples of heat transfer > Does the air get colder when the wind blows? (Pentronic News 2013 #1)

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