Why aren't there icicles on every house in winter?

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

QUESTIONS ANSWERS

QUESTION: Along our road are a number of single homes of the same type. Their roofs are slightly sloped and the outer layer consists of bitumen membranes. At the end of February I noticed that some of the houses had icicles hanging down from their roof but other houses had no icicles at all. There was a lot of snow on every roof and the depth of this snow blanket varied quite a lot. Does this snow depth have any influence on whether icicles form?

Katarina K

ANSWER: Heat is transported from the attic space under the roof and then through the roof and snow blanket to the surroundings (see Figure 1). The temperature of the upper surface of the roof is one of the factors that determine whether icicles form. If this temperature is above zero then the snow will melt and water will run down the roof. However, if the temperature of the outdoor air is below zero, then this water will freeze at the base of the roof and icicles can form. The size of the heat flow through the roof depends on a number of factors, including the air temperature inside the house's attic. This in turn is influenced by factors such as the thickness of the attic insulation, the design of the attic ventilation and the leakage of warm indoor air into the attic.

Heat is transported by means of convection and radiation to the underside of the roof and then by means of heat conduction through the roof to the outside of the roof surface. From there, the heat transport occurs by means of heat conduction through the snow up to the upper surface of the snow blanket and then out from the surface by means of convection and radiation.

The higher the temperature is under the roof, the warmer the outer surface of the roof and thereby the greater the risk that the snow will melt. The snow blanket on the roof functions as a layer of insulation and reduces the heat flow (see Figure 2). If the thickness of the snow blanket increases, the heat flow is further reduced. However, the temperature of the upper surface of the roof will also increase, and this can make the snow melt. The heat conductivity of snow depends on such factors as the structure of the snowflakes or granules and the snow's density. For example, at a density of 250 kg/m^3 the heat conductivity is 0.1 – 0.2 W/m K, which is about the same magnitude as the heat conductivity of wood.

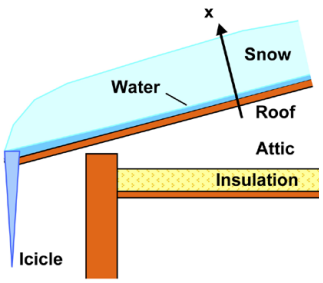

FIGURE 1

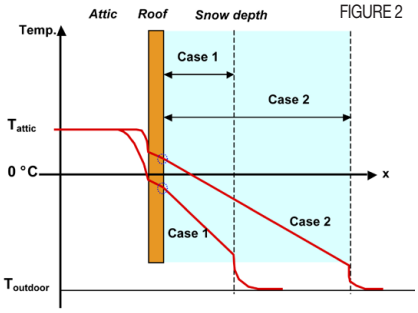

FIGURE 2

SNOW-COVERED SENSORS

One reason why there are no icicles on some houses can therefore be that they have a colder attic. In turn, this can be because the attic has additional insulation. Another reason why there are no icicles can be that there is only a thin layer of snow on the roof. The variation in the depth of the snow blanket is caused by such factors as the local wind conditions during a snowfall. Probably it is a combination of both these reasons that determines whether icicles form or not. Temperature sensors that are set up outdoors can measure incorrectly if they are covered in snow. True, snow is not an efficient insulation material, but it still reduces the heat flow going past the sensor, which can therefore give incorrect readings.

If you have comments or questions, contact Professor Dan Loyd at the Institute of Technology at Linköping University: dan.loyd@liu.see