Condensed steam – a problem for both spectacles and temperature sensors

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

QUESTIONS ANSWERS

QUESTION: During the winter my spectacles sometimes – but not always – steam up when I go inside my house. What conditions must exist for my spectacles to steam up?

Mats F

ANSWER: Whether or not your spectacles steam up depends on their temperature, geometry and other properties, and also on the temperature and humidity of the indoor environment.

The humidity of the air can be described in several different ways. One way is to use the ratio between the mass of the water vapour and the mass of the dry air. This ratio is often called the vapour ratio. The concept of dry air includes all the gases in the air except the water vapour. Another way is to state the specific humidity, which is the ratio between the water vapour's mass and the mass of the moist air (the total mass of all the gases in the air). Normally, the numerical difference between these two ratios is small but it is important to distinguish between the two concepts when doing your calculations. The water content in the air can also be stated by using the concept of relative humidity (relative vapour pressure), which is the relationship between the water vapour's partial pressure at a specific temperature and its partial pressure at the same temperature when the air is saturated with water vapour (the saturation vapour pressure). Unfortunately, the concepts described above are not always specified in the same way. For example, other scientific and engineering sources can use the term "vapour concentration", "water content", "humidity by mass" or "specific humidity" to describe the vapour ratio (the ratio between the water vapour mass and the dry air mass). Therefore you should always check what a specific writer is referring to.

DEW POINT

If the air temperature is – 5 °C and the relative humidity is 90%, the vapour ratio is 0.0025 kg of water per 1 kg of dry air. For a temperature of + 22 °C and a relative humidity of 35%, the vapour ratio is 0.0060 kg of water per 1 kg of dry air. If you lower the temperature of an air mass, its relative humidity increases but the vapour ratio remains constant. When you have lowered the temperature to what is called the dew point, the air is saturated with water vapour and the relative humidity is then 100%. In the first example mentioned above, the dew point is – 6 °C and in the second example it is + 7 °C. If the saturated air comes into contact with an object that has a lower temperature than the dew point, then the water vapour can condense onto the object.

When we are outside during the cold winter months our spectacles cool down. The flow of heat from the face to the spectacles, and the flow of heat from the spectacles to the surroundings determine the temperature of the spectacles. When we go indoors, the indoor air close to our cold spectacles cools down. If the temperature of the spectacles is lower than the dew point of the indoor air, condensation will form on the spectacles in the process known as "steaming up". The indoor air then gradually warms up the spectacles and the condensation vaporises again.

LONGER RESPONSE TIME

If a cold sensor comes into contact with a warm, moist air flow, the conditions can be such that the sensor steams up. A sensor with condensed steam on it has a longer response time than a dry sensor because some of the heat flow from the air to the sensor is used to turn the condensation back into vapour. In addition to the amount of moisture on the sensor, the sensor's design and the air flow also influence how much longer the response time becomes. The longer response time can sometimes lead to undesirable results if the sensor is being used to control a process.

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