DOES THE ROOM GET COLDER WHEN YOU USE A DESK FAN?

QUESTION: Over the past year I've often worked from home due to the pandemic and sometimes it gets quite warm at my work station. When that happens I often use a desk fan, which quickly cools things down. Shouldn't it become a bit warmer in the room when I switch the fan on? The fan has a 25 W motor.

Liv G

ANSWER: It is true that when a desk fan is switched on, the ambient air temperature in the room does increase slightly but the increase is very small. At the same time, we feel that the room is becoming cooler. To resolve this contradiction, let us first examine a ceramic vase which is standing on the desk and then the person behind the desk.

The temperature of the ceramic vase is measured with a thermometer. Scattered about the room are objects like a computer, printer, lamps, radiators etc., which, when they are on, are warmer than the room's air temperature. Normally, the vase is therefore supplied with a net heat flow via radiation, which increases the vase's temperature. When the vase's temperature exceeds the air temperature, the vase transfers heat to the air via natural convection. The vase's heat exchange with the desk occurs via thermal conduction. The vase acquires a temperature which is determined by the fact that the heat flow to the vase must be equal to the heat flow from it. The vase's temperature will be slightly higher than the air temperature. When we switch the desk fan on, the power of its motor causes the air passing by the vase to become slightly warmer and the vase's temperature to increase, but the increase is very small.

In contrast, when we switch the desk fan on, the individual at the desk is affected in a totally different way than the vase. A person's body is constantly generating heat (metabolism), which is transferred to the surroundings. Skin that is not covered by clothing has a surface temperature of over 30 °C and the surface temperature of clothing tends to be 25 to 30 °C. In this case, the body's surface temperature is higher than the air temperature and the result is a convective heat flow from the body to the air. Most parts of the room have a lower temperature than the body's surface temperature, which gives a net heat flow from the body to the room via radiation. The convective heat flow Q to the air depends on the heat-transferring area A, the convective heat transfer coefficient h, and the difference between the body's surface temperature $T_{surf.}$ and the air temperature T_{air}: $Q = A\,h\,(T_{surf.} - T_{air})$.

The computers, printers, lamps etc. which are used in the home office are constantly generating heat, as is the person behind the desk. This means that the temperature in the room rises throughout the day. The increasing air temperature T_{air} reduces the convective heat flow from the body: $Q = A\,h\,(T_{surf.} - T_{air})$. The net heat flow via radiation also decreases as the room temperature increases. The body's heat generation Q remains approximately the same throughout the day, which means that the body's surface temperature $T_{surf.}$ must increase so that it can get rid of as much heat as before. We feel that we are getting hot. If we start to sweat, the moisture is given off to the surroundings in the form of water vapour. The phase transition from liquid to water vapour requires heat, which is drawn from the body, which in turn means that the heat transfer from the body increases.

When we switch on the desk fan, the air temperature increases slightly but the increase is very small. The air velocity around the body increases, which means that the heat transfer coefficient h increases. The result is forced convection instead of natural convection. The convective heat flow from the body increases, even though the temperature difference $(T_{surf.} - T_{air})$ has decreased. In contrast, the radiation is not directly affected by the air velocity. The increased heat transfer from the body lowers the body's temperature and we feel that it has become cooler in the room, even though the air temperature has increased slightly.

QUESTION ? ANSWER

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

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