HEATING GLÖGG – A CURRENT THERMAL PROBLEM

QUESTION ? ANSWER

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

QUESTION: Christmas is fast approaching, when it is a common custom in Sweden to offer guests hot mulled wine called glögg. Unfortunately the glögg is often lukewarm and not at all hot. What is an easy way to ensure that the glögg really is hot when it is served?

Nils J

ANSWER: We assume that the hot glögg in the serving vessel has a temperature of 50 °C and the glögg mug has a room temperature of 20 °C. When the glögg is poured into the mug, heat from the glögg is transferred to the mug via convection. The thermal resistance between the glögg and the mug's inner wall is small, which means that the temperature rapidly equalises.

When the mug's surface temperature becomes higher than the room temperature, heat is transferred from the glögg to the surroundings via convection to the mug, thermal conduction inside the mug wall, and then onward from the mug via convection and radiation. Heat is also transferred directly from the glögg surface to the surroundings via convection and radiation. The glögg is further cooled via the evaporation (a phase transition that requires heat) occurring from the surface of the liquid. The glögg temperature is constantly falling. The temperature sequence is shown in Figure 1.

Figure 2.

To determine the glögg temperature after the temperature equalisation, perhaps the simplest method is to measure it. You can also very roughly estimate the glögg's temperature with the aid of the following equation:

$$m_{mug}\, c_{pmug}\, (T_{glögg} - T_{room}) = m_{glögg}\, c_{pglögg}\, (T_{serving} - T_{glögg})$$

where, m is the mass in kg, c_p the specific heat capacity in Ws/(kg K) and T the temperature in °C.

As an example we can study a ceramic mug – Figure 2 – with a weight of 0.14 kg and a specific heat capacity of 850 Ws/(kg K). We pour in 100 ml (0.1 kg) of alcohol-free glögg with a serving temperature of 50 °C and specific heat capacity of 4200 Ws/(kg K). If the room temperature is 20 °C the glögg temperature will be 43 °C.

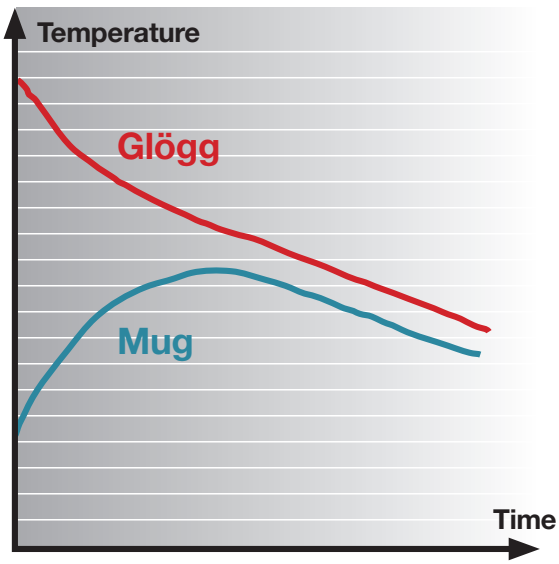

Figure 1.

The temperature reduction relative to 50 °C is so great that it is noticeable.

If the glögg mugs are heated to 50 °C there will be no temperature reduction when the glögg is poured into the mug. Preheating the mugs with hot water is a simple method of achieving the desired temperature. Another method is to increase the glögg's serving temperature to achieve the desired glögg temperature after the temperature equalisation. If you use glögg that contains alcohol, however, you must not increase the temperature too much – alcohol boils at 78 °C.

The heat flow to the surroundings means that after the temperature equalisation, the glögg temperature falls fairly quickly. In a preheated mug of the same type as the above example, we can measure a temperature reduction of just under 1 °C per minute. When the glögg contents in the mug are reduced, the glögg cools faster.

If the glögg is to be served in a thin plastic mug, the initial temperature reduction will be very small but the cooling-off speed will be higher than for the ceramic mug. If you use two plastic mugs with one inside the other, you create a small air gap between the mugs, which increases the thermal resistance and slows down the fall in temperature. So it can be worth considering which type of mug to use when it's time to heat your glögg!

Merry Christmas and Happy New Year!

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