Transfer of Heat by Convection

Ian Jacobs: Physics Advisor: KVIS, Rayong, Thailand

Convection

Convection currents in water are readily demonstrated with a bottle of salt water containing suspended plastic chips. Gentle heating of the water at the bottom or on the outside of the bottle sets up turbulent flow driven by buoyancy forces in the gravitational field. The effect is to transfer less dense warmed water upwards.

The transfer of heat by conduction is amenable to calculation but heat transfer by convection is a chaotic turbulent flow process that depends on many factors and must be measured in each different situation.

Equipment

You are asked to study heat transfer by convection with a hotplate, a metal pan, containers, different fillings and three thermocouples.

Liquids: *you may select water, and/or honey, and/or oil.*

Semi-solids: *you may select agar water-gel, and/or water with cotton wool filling, and/or damp cooked rice.* (All have close to the thermal conductivity of pure water and will have little or no convection.)

Independence: *you may substitute filings and/or containers of your own.*

Containers: *you may select two or three metal cans, plastic sauce bottles, or a combination of the two.*

Procedure

1 Select cans or plastic bottles and fillings.

2 Write down what you are comparing and what you expect to find.

3 Place the containers in the hot-water bath with thermocouples a cm or so beneath the top of the fillings and plot temperature/time curves.

4 Discuss the graphs and what they mean in terms of convection and conduction in a short written report.

Preliminary results for water, honey and agar water-gel in cylindrical plastic sauce bottles, 15 cm high, 1.2 mm thick and 16.5 cm in circumference.

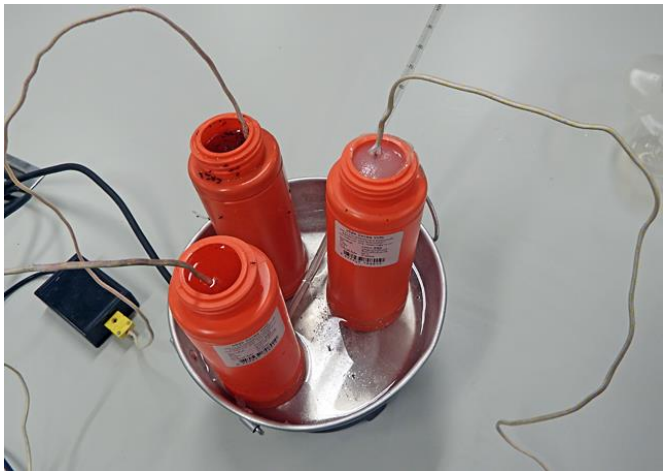

Fig 1 – sauce bottles standing in hot water.

The bottles with thermocouples were placed at the same time in one cm of hot water maintained at ~70 ºC on a low power setting to a hot-plate. The thermocouples were placed centrally one cm below the surface of the filling in each bottle.

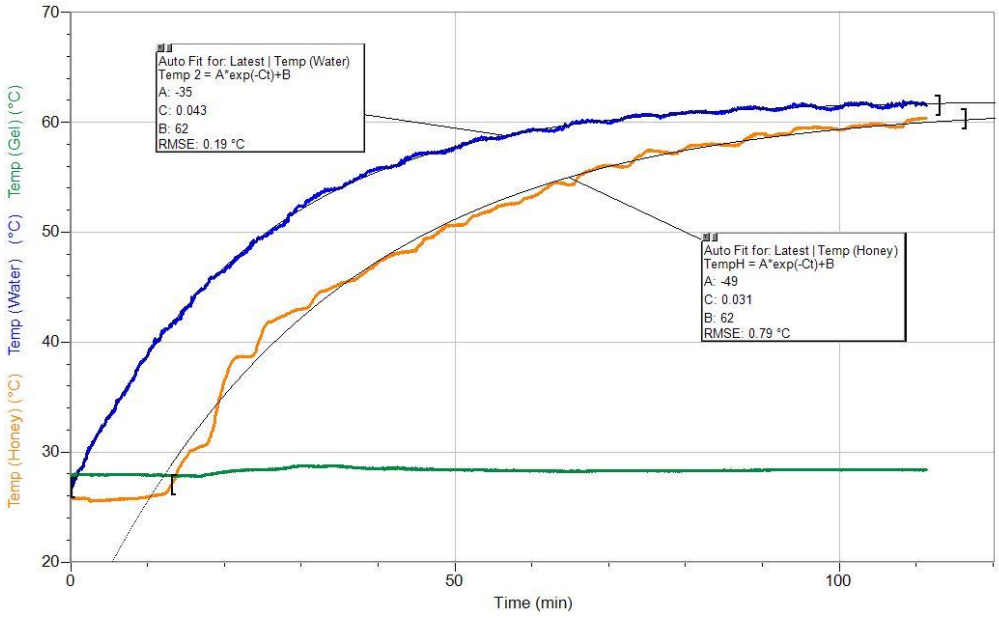

Fig 2 –water (blue) honey (red) and agar gel (green) that remains solid below 70 °C.

Points to ponder

What might be the reason for the delay in the response of honey? Why is the honey curve irregular at low temperatures? Why are the top temperatures less than 70º? If you used a metal coke can would the green curve be that flat? Why are the water and honey temperature-time curves approximately exponential?