Hot Disk

The leader in transient techniques

Thermal Conductivity measurements on Milk with various fat contents with the Hot Disk® Thermal Constants Analyser

Low Viscosity Liquids and the Hot Disk thermal constants analyser

The Hot Disk thermal constants analyser can be used for many applications including measurements on low viscosity liquids. Measurements carried out on water yields very good results (typically 0.61W/mK at RT), but measurements have also been carried out on Methanol which is a liquid with even lower viscosity than water.

When measuring on low viscosity liquids, three parameters are more important than when measuring solids. First, the power given by the sensor spiral must be low to avoid convection in the sample. Second, the measurement must often be restricted to last for 1 second roughly. Third, the sensor choice is crucial for the accuracy of the measurements. Sensors with radii 2-3 mm are usually a good choice since the measurement time can be kept short.

Measurements on more viscous liquids (different oils, paint samples etc.) can usually be measured with slightly larger sensors and also longer measurement times.

Hot Disk AB has for several years successfully carried out measurements on low viscosity liquids.

Introduction

In this Application note four different milk products with fat content (given by the manufacturer) <0.1 %, 0.5 %,1.5 % and 3 % were compared in order to investigate if the Hot Disk Thermal Constants Anlyser can be used to determine fat content in diary products.

Measurements and Results

In order to make sure that the measurements were performed at the same temperature, a cylinder made of Aluminium (diameter 80 mm and height 60 mm), in which 4 holes (diameter 20 mm and depth 50 mm) were drilled, was used. These holes were then filled with the different qualities of milk.

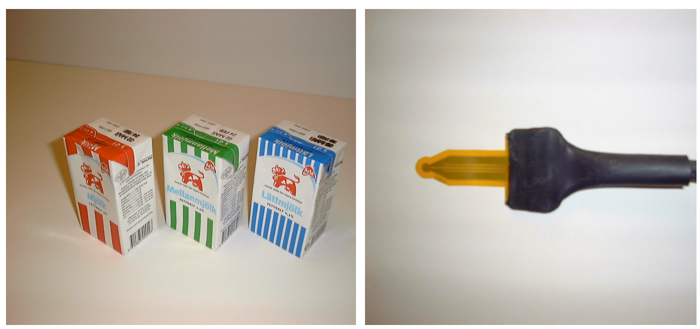

Fig. 1. *(Left) The 3 milk samples with highest fat content and (Right) the sensor used for the measurements (C7577).*

A Kapton insulated probe (design 7577, Fig. 1) was successively dipped into the different milk samples (Fig. 1). The diameter of the sensing spiral in the probe was about 4 mm and the Kapton insulation on both sides of the spiral had a thickness of 13 µm and the thermal conductivity of this insulation was 0.12 $Wm^{-1}K^{-1}$.

The experiments were performed with a standard Hot Disk Bridge Thermal Constants Analyser and the transient recordings were limited to 2.5 seconds. The analysis was then performed with the assumption that the heat capacity per unit volume was 4.17 $MJm^{-3}K^{-1}$ Points no. 17 to 77 out of a total of 200 collected during the transient recording were used. This means that data points recorded beyond 0.96 seconds were not considered and as a consequence no sign of natural convection could be seen. The total output of power during the transient was 0.15 W resulting in a temperature increase, over the time window used for evaluating the results, of around 1.7 K. The probing depth was 0.8 mm and the mean deviation around the fitted line was less than 0.004 K.

About the Hot Disk instrument
The Hot Disk Thermal Constants Analyser is a system designed to conveniently measure the thermal transport properties of a sample: thermal conductivity, thermal diffusivity and specific heat. The system is based on a patented Transient Plane Source (TPS) technique, which can be used to study materials with thermal conductivities from 0.005 to 500 W/mK and covering a temperature range from 30 to 1000K.

The following modes of operation are available with the Hot Disk instrument

1) Basic method: The sensor is sandwiched between 2 sample. This method also features a single sided option.
2) Thin Film method: A special extremely sensitive sensor is sandwiched between 2 pieces of the film (10-500µm).
3) Slab method: For very conducting materials (> 10W/mK like SiC, Cu etc.).
4) Anisotropic method: This method measures the anisotropic thermal conductivity and diffusivity of a uni-axial sample.
5) Cp-determination: Determines Cp of solid samples.

For more information, please visit **www.hotdisk.se** or contact Hot Disk AB in Sweden.

The results from the measurements were as follows:

Fat concentration (%)	**Thermal Conductivity ($Wm^{-1}K^{-1}$)**
<0.1	0.5634 +/- 0.0003
0.5	0.5563 +/- 0.0008
1.5	0.5485 +/- 0.0007
3	0.5369 +/- 0.0008

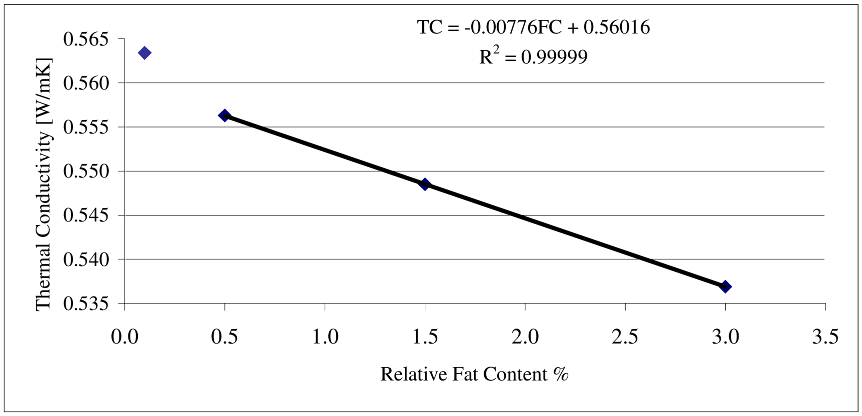

***Fig. 2.** The thermal conductivity dependence on fat content in milk is perfectly linear. The deviating point for the skimmed milk sample (<0.1% fat) can possibly be due to even lower fat content.*

Two measurements were made on each milk sample and the probe was moved from one hole to another between the measurements. First the four samples were measured with only a few minutes between each measurement. Later a similar second series of measurements were made after about one hour.

The three last concentrations indicate a perfectly linear dependence (Fig. 2.) of the thermal conductivity on the fat concentration. Comparing the change in thermal conductivity (with a mean deviation of 0.0007 $Wm^{-1}K^{-1}$ as in these experiments) with the change in fat concentration indicates that it is possible to determine the fat concentration within about 0.09 %.

Conclusive remarks

It has been shown that the thermal conductivity of low viscosity liquids can be measured with the Hot Disk thermal constants analyser and also that the sensitivity of the instrument is sufficient when it comes to determining the fat content of milk.

Other examples of applications for low viscosity liquid measurements are for instance water-anti freezer mixtures, where the anti-freezer content can be measured.

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