Anisotropic Thermal Properties Measurements of Electrically Heated Cigarettes

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Measurement Setup

The sample for measurements is composed of commercially available cigarettes for tobacco heating systems. Two sample pieces are prepared for double-sided setup; each sample piece is intentionally bundled with 15 cigarettes, which yields a total diameter of approximately 27 mm (Figure 1) - about two-fold larger as the selected probe (Hot Disk Sensor) diameter.

The height of the tobacco section of the cigarette is 11.5 mm. The Hot Disk Sensor is sandwiched between two sample pieces (Figure 2).

Figure 1 - one sample "bundled"

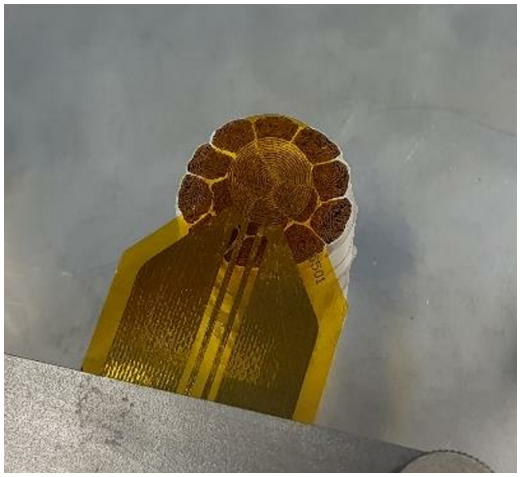

Figure 2: "bundled" sample with Hot Disk Sensor, the second sample is placed on top of the sensor

Measurement Parameters (excerpt)

Measurement module:	*Hot Disk "Anisotropic" with TPS 2500S*
Measurement time:	*10 seconds*
Temperature:	*Room Temperature*
Volumetric heat capacity: *(required for Anisotropic measurements)*	*0.36 MJ/m3K**

** This value was taken from the tabular data for general cigarettes and should be adjusted for each specific sample for correct calculations of anisotropic thermal properties. The volumetric heat capacity is equal to the apparent density of the sample multiplied by the specific heat of the tobacco.*

Results

	Axial Thermal Conductivity, W/m/K	Axial Thermal Diffusivity, mm^2/s	Radial Thermal Conductivity, W/m/K	Radial Thermal Diffusivity, mm^2/s	Axial Probing Depth, mm	Radial Probing Depth, mm
ave.	1.059	2.943	0.215	0.598	10.82	4.88
std., %	0.89	0.89	1.63	1.63	0.45	0.82

Table 1: Results of Hot Disk Anisotropic measurements

The results collected in Table 1 show the average values of 5 measurements with 60 min waiting time between each measurement. The radial properties represent a geometrical average of the properties in the x- and y- direction of the sensor ("in-plane"), whereas the axial properties represent the properties in the z- direction of the sensor ("through-plane"). The probing depth indicates the distance of the heat that travels from the sensor spiral to the sample's body during the experiment.

In this setup the heat conductivity "through-plane" (axial) is about 5 times higher compared to the heat conductivity "in-plane" (radial).

It is found that the tobacco flakes are not homogeneously distributed (in the radial direction) in this particular sample architecture. To improve and make the results more representative for a single cigarette, a single cigarette sample with a diameter greater than 26 mm for testing is suggested. By doing so, the wrapping paper between each cigarette and the random distribution of the tobacco flakes may no longer impact the measurement. Moreover, we recommend increasing the height of the tobacco section so that the heat can propagate further than 11.5 mm in the axial direction. This will allow one to prolong the measurement time to 20 sec, which hence increases the probing depth in the radial direction. As a result, the measured thermal conductivity will be more representative.

The measurements carried out that the Anisotropic Measurement Module of the Hot Disk System enables the resolution of anisotropic thermophysical properties of complexly structured materials.