Hot Disk®

The leader in transient techniques

Measure Anisotropic thermal concuctivity and diffusivity in fiber enforced polymers with the Hot Disk Thermal Constants Analyser

Measure direction dependent thermal conductivity and diffusivity with the Hot Disk Thermal Constants Analyser.

Measurements with the Hot Disk Thermal Constants Analyser and the Anisotropic module have been carried out several types of samples. In recent work by Lundström et. al. **[1]** anisotropic properties in cast γ-TiAl alloys were investigated. The measurements were carried out over a temperature interval of almost 700°C and an average of round about 15% of anisotropy could be detected. Typically for these materials the thermal conductivity increased from 12-14 W/mK to 20-22 W/mK over the given temperature period.

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 *(please see next page)*

Introduction

In this application note 3 samples made out of a polycarbonate, Lexan 123 R, matrix reinforced with different amounts of nanofibres from Hyperion Catalysis (FIBRIL) are tested with the Hot Disk Thermal Constants Analyser and the anisotropic module. The fibers lie mainly in the plane of the sensor.

Experimental and Results

Due to the sample sizes and thermal properties of the samples the sensor radius, power and time chosen for the measurements were 2.001mm, 0.002W and 10s respectively. Due to the anisotropic properties of the samples the anisotropic method were chosen as measurement method. This method requires the C_p value to be known and therefor a series of measurements were carried out on the sample pieces in order to determine the specific heat capacity. For the C_p measurements the reference measurement was carried out over 40s and the power was 0.2W. When a sample measurement was carried out the power was 0.23W. The results for the C_p measurements and the thermal conductivity/diffusivity measurements are displayed in table 1. The axial direction is the direction perpendicular to the plane of the sensor and the radial direction is the direction in the plane of the sensor, see fig. 1. The conductivity and diffusivity values are plotted vs. fiber amount in fig. 2. Each mean is calculated out of 3 successive measurements.

Table 1. *Results for the thermal transport properties of the 3 samples.*

		λ_{axial} [W/mK]	κ_{axial} [mm²/s]	λ_{radial} [W/mK]	κ_{radial} [mm²/s]
Sample 1%	**Average**	0.1061	0.0811	0.230	0.176
	Stdev	0.0007	0.0005	0.002	0.002
Sample 2.5%	**Average**	0.0939	0.0652	0.302	0.2099
	Stdev	0.0006	0.0004	0.001	0.0009
Sample 5%	**Average**	0.1043	0.0724	0.3502	0.2429
	Stdev	0.0002	0.0001	0.0004	0.0003

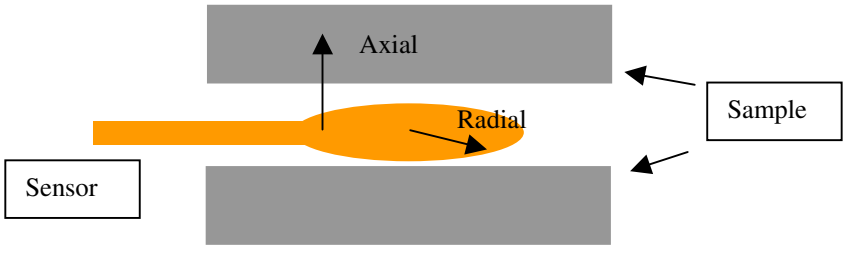

Fig. 1. *The sample set-up for an anisotropic measurement.*

1) ***Basic method***: The sensor is sandwiched between 2 sample pieces. 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.

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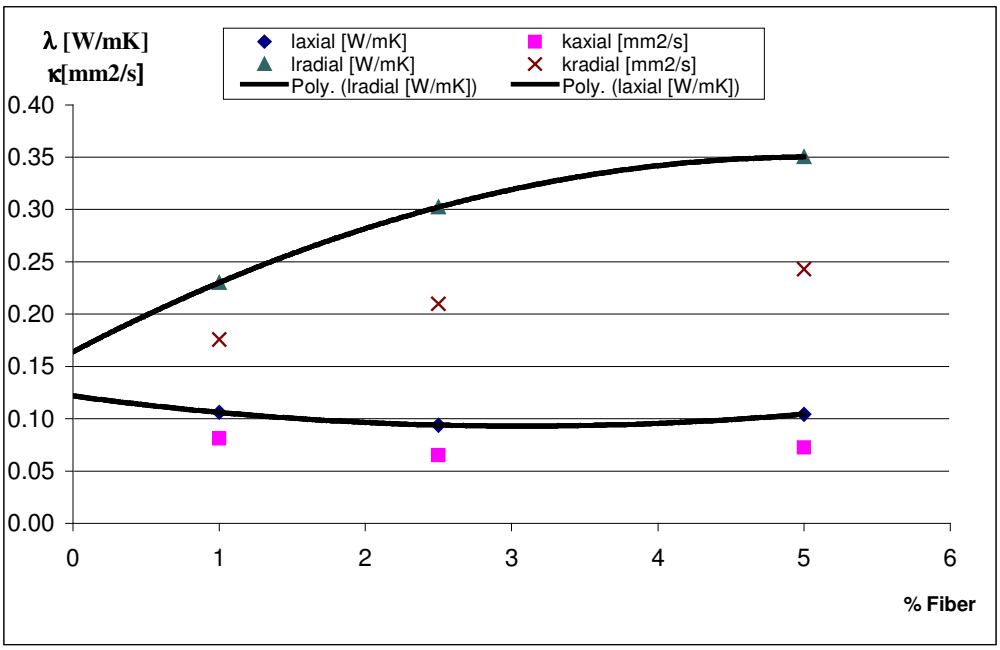

Fig. 2. *Thermal conductivity and diffusivity plotted against fiber content. The extrapolated lines indicate that the matrix concuctivity lies around 0.15W/mK, which indeed is the aproximate thermal conductivity given by the manufacturer.*

Conclusion

The thermal transport properties, diffusivity and conductivity, are both direction dependent in these samples and there is a clear connection between the amount of fibrers and the degree of anisotropy for the conductivity. It is clearly seen that when extrapolating the values to 0% fiber, the thermal conductivity values converge towards ~ 0.15 W/mK, the approximate given polymer matrix conductivity by the manufacturer.

References

[1] Lundström et. al. **Anisotropy in Thermal transport Properties of Cast γ-TiAl alloys**, Z. Metallkd. 92 (2001) 11

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