APPLICATION NOTE

Polymers – Laser Flash Analysis

CFRP and GFRP: Customized Thermal Management for High-Tech Applications

Fabia Beckstein, Applications Laboratory Selb

Introduction

CFRP (carbon fiber-reinforced plastic) and GFRP (glass fiber-reinforced plastic) are indispensable in numerous high-tech applications due to their unique material properties. Their key characteristics are high strength combined with low weight. This, along with their low thermal conductivity, makes them ideal for high-tech applications in aerospace, automotive and electronics. Their directional (anisotropic) thermal properties play a special role in their application, as the thermal conductivity along the fibers is higher than across them. The layered structure allows the fibers to be oriented to either dissipate heat in a targeted manner or to effectively insulate areas. This flexibility enables tailor-made solutions such as the minimization of temperature variations in satellites or the regulation of heat in batteries.

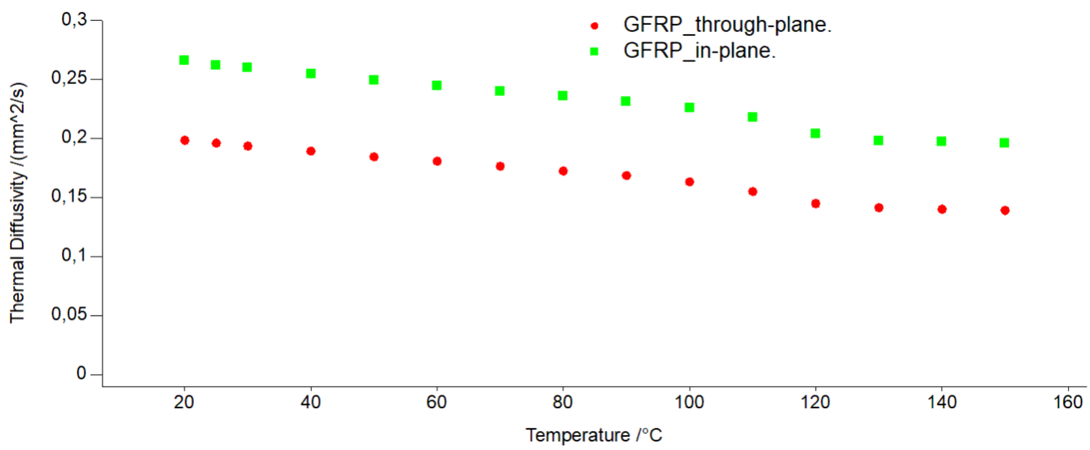
Measurement Conditions and Results

For the determination of thermal properties, Laser/Light Flash Analysis is particularly well suited. Initially, the thermal diffusivity – which is a function of direction – is determined using an instrument such as the LFA 717 *HyperFlash*®. Subsequently, the data on density and specific heat capacity can be applied in order to calculate the thermal conductivity, which is also a function of direction. The measurement conditions are detailed in table 1.

Table 1 Measurement parameters

Analysis instrument	LFA 717 *HyperFlash*®
Sample size	10 mm x 10 mm x 2.5 mm – through-plane Several strips of 10 mm x 2.5 mm – in-plane
Sample holders	10 mm square – through-plane 10 mm laminate sample holder – in-plane
Temperature points	20 to 150°C in steps of 10 K
Atmosphere	100 ml/min, N_2

Figure 1 shows the thermal diffusivity of GFRP in the through-plane direction (perpendicular to the fiber) and in the in-plane direction (parallel to the fiber). The thermal diffusivity decreases slightly with increasing temperature. Between 110°C and 130°C, a small change in gradient can be seen, indicating the glass transition of the polymer matrix. The in-plane thermal diffusivity is about 35 to 40% higher than in the through-plane direction.



1 Thermal diffusivity of a GFRP sample, perpendicular (through-plane) and parallel (in-plane) to the fiber direction.

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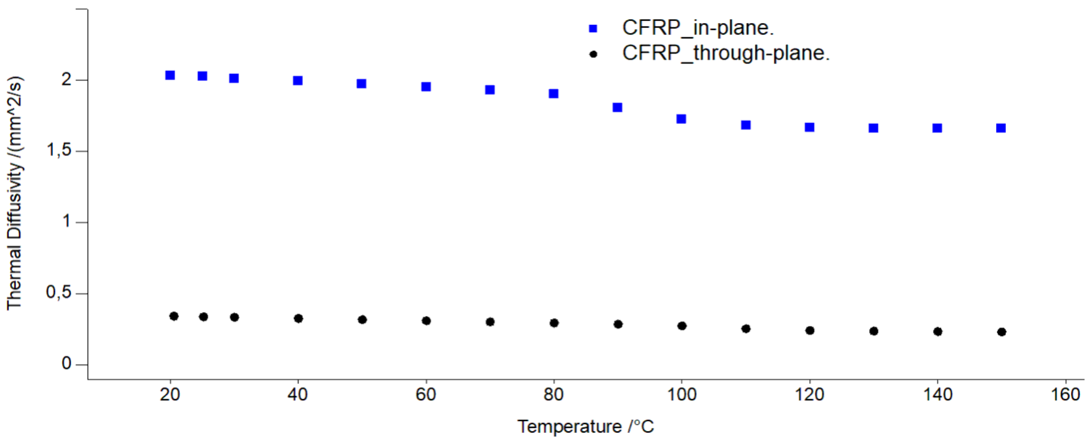
NETZSCH-Gerätebau GmbH
Wittelsbacherstraße 42 · 95100 Selb · Germany
Phone: +49 9287/881-0 · Fax: +49 9287/881505
at@netzsch.com · www.netzsch.com

A CFRP material is similarly shown in Figure 2. Again, the in-plane thermal diffusivity is higher than the through-plane thermal diffusivity.

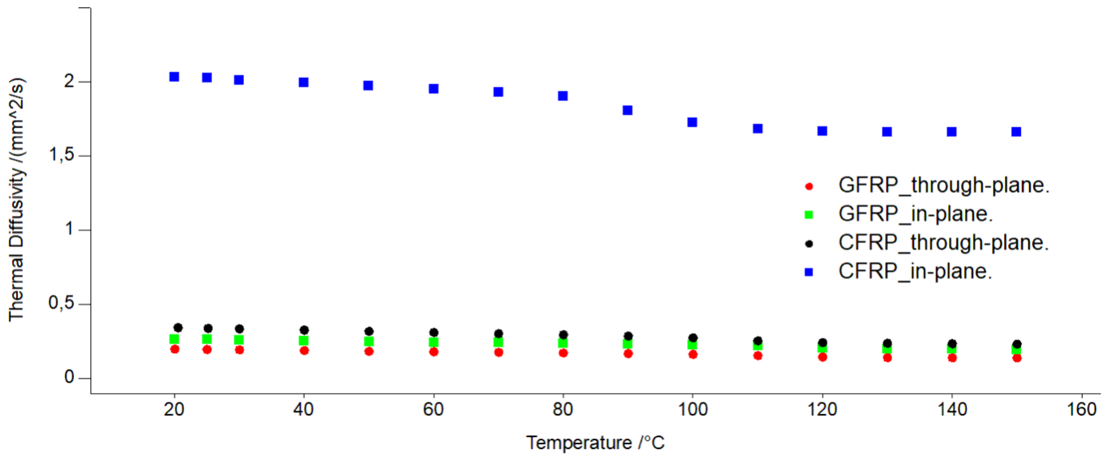
For the CFRP material, the difference between the directions is considerably greater than for the GFRP material. It's not 35 to 40% as for the GFRP sample, but 500 to 600%. This striking difference is due to the carbon fibers, which possess a much higher thermal diffusivity than the glass fibers. This is particularly clear in figure 3, which summarizes all of the measurements.

Conclusion

The LFA method can also determine thermal diffusivity and thermal conductivity as a function of direction, providing important data for the design and construction of high-tech applications.



2 Thermal diffusivity of a CFRP sample, perpendicular (through-plane) and parallel (in-plane) to the fiber direction.



3 Thermal diffusivity of GFRP and CFRP samples in different directions.

NETZSCH-Gerätebau GmbH
Wittelsbacherstraße 42 · 95100 Selb · Germany
Phone: +49 9287/881-0 · Fax: +49 9287/881505
at@netzsch.com · www.netzsch.com