RCF - GEOMETRICAL CHARACTERIZATION

Dr. Hubert Schmid, Isabel Schmid
IST AG – Fiber & Particle Analysis
Vilters (Switzerland)

Abstract

The length and other geometrical properties of rCF (recycled carbon fibers) are determinant parameters in the production of composite materials containing rCF. Depending of the recycling procedure the rCF staple fibers (fibers with finite length) are available as roving snippets (fiber collectives) or single fibers.

The geometrical characterization of rCF fibers, roving snippets, yarns and nonwovens is done with the measurement system FibreShape. The main focus in this presentation is on the length analysis of the rCF, but the analysis of fiber width, orientation and texture are also available in FibreShape. The geometrical characterization of fibers provides the information to predict the quality, strength and uniformity of a fiber reinforced composite.

Introduction

FibreShape provides the user with the safety of a standardized quality measurement (1). Knowing the properties of a raw material is the first step to create a high-quality product. FibreShape can be used for entrance control of the length and width of rCF but also to control the fiber length as part of the processing chain (2).

In order to obtain the images of the rCF the FibreShape system relies on scanners with transmissive light units and a digital microscope also operated in transmissive light mode. The analysis, visualization and evaluation are done by the FibreShape software. FibreShape's use of scanners is crucial for its success. They enable the characterization of advanced geometrical properties but at the same time support specimen of large sizes and the measurement of many specimen in a single batch. Microscopes are employed when a higher resolution is required such as for the width measurement in the range of microns (3).

Discussion

The fiber length is a key characteristic important in the production of roving snippets, yarns and nonwovens. When working with short-fiber composites it has to be considered that for the transfer of stress there is relatively little interface per fiber. The so-called "critical length" of carbon fibers is approximately 5 mm. This length is necessary to ensure that the fiber can be stressed to its full strength (4).

Depending on the compound, different rCF lengths are realizable. (Hybrid-)yarns from rCF or thermoplastic foils work with a rCF length of about 15 mm to 80 mm. In the case of injection molding, short fibers below 6 mm are used. RCF that result from pyrolysis can either be used for injection molding if of short length or for nonvowens in case of bigger length.

The measurement of length and other geometrical properties of different rCF materials are shown in three samples that have been provided by three German Institutes: Faserinstitut Bremen, STFI and DITF:

- Single rCF fibers: length and width measurement
- Roving snippets of rCF: length and width measurement
- rCF-nylon-hybridyarns: width, orientation of wrappers and distances between wrappers

<u>Single rCF</u>

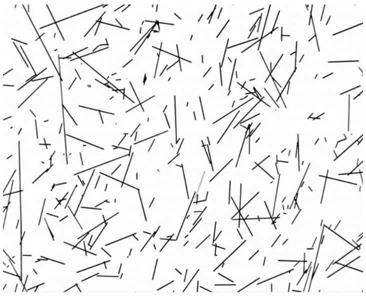

Fig. 1: Single rCF scanned at 3200 dpi

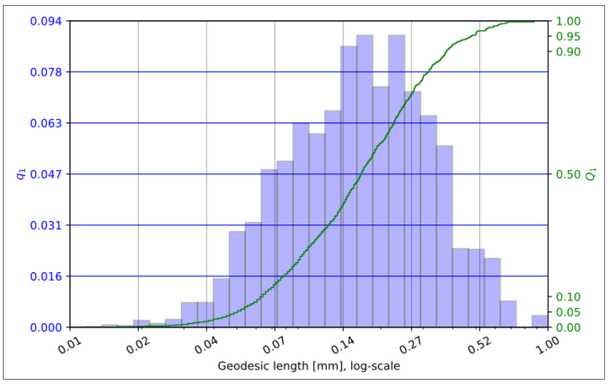

Fig. 2: Distribution density (q1) of the geodesic length, weighted by length

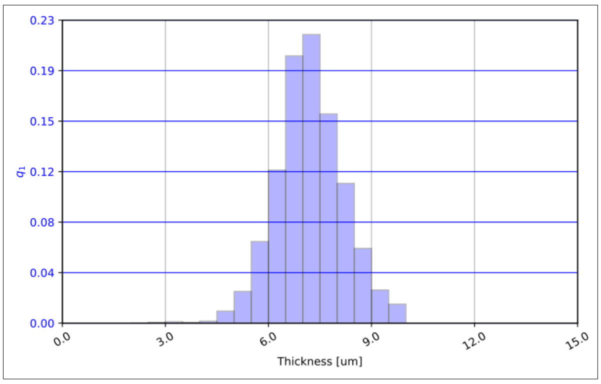

Fig. 3: Distribution density (q1) of the width, weighted by length

The histogram of the distribution density shows a distribution from 0,025 mm to 1mm. In total 1972 objects were analyzed. The average fiber length is 0,2 mm. The control of the area ratio, in this sample 9,62%, ensures that the fiber density is not too high. The width of the rCF varies from 3 µm to 11 µm.

<u>Roving snippets of rCF</u>

The sample of the analyzed roving snippets counts 118 objects (fig. 4). The roving snippets have a length of 4 mm to approximately 13 mm (fig. 5). The width distribution shows some scattering. The distribution varies from 0,5 mm to 3,5 mm (fig. 6).

Fig. 4: Roving snippets scanned at 3200 dpi

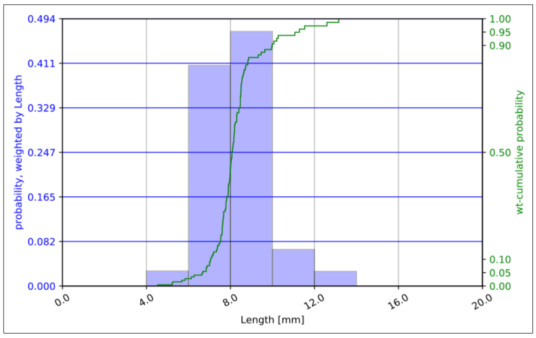

Fig. 5: Distribution density (q1) of the length of roving snippets, weighted by length

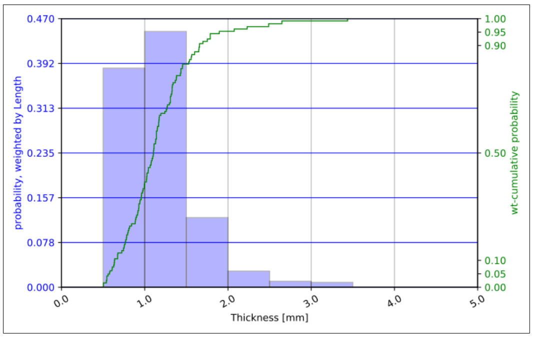

Fig. 6: Distribution density (q1) of the width, weighted by length

RCF-nylon-hybridyarns

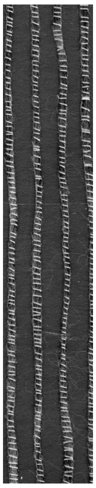

Fig. 7

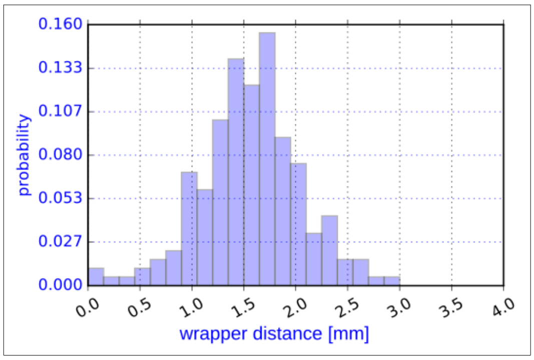

Fig. 8: Distances between wrappers

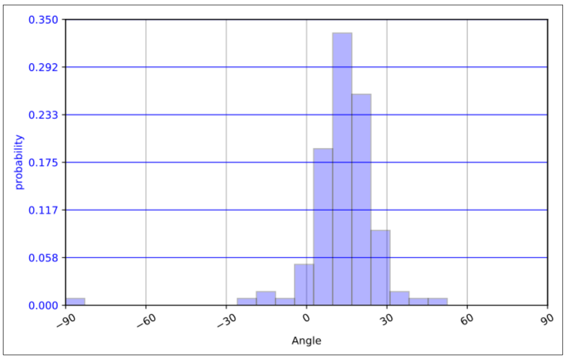

Fig. 9: Orientation - Distribution density (q1) of the angles of the wrappers

Fig. 7 shows the rCF-nylon-hybridyarns scanned in reflective light mode at 1200 dpi. The average width (mean value) of the wrappers measured with the parameter "minor axis of Legendre ellipse" is 0,56 mm (+/- 0,15 mm). The results of the study of the orientation of the wrappers and the distances between the wrappers can be seen in fig. 8 and fig. 9. The distribution density of the angles of the wrappers vary from approximately -25 to 55. The value 0 represents the x-axis. The distances between the wrappers vary from 0 mm to 3 mm.

Summary

Sampling inspection of purity or uniformity or the control of geometric characteristics help to improve later process steps. Knowing the properties of the rCF as raw material or during different process steps allows to detect regularities or irregularities. The advantage of FibreShape is the support of a wide size range and the ability to measure hundreds to thousands of objects with a single batch for statistically significant results.

Acknowledgements

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Literature

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