MEASURING THE LENGTH AND WIDTH OF FIBERS ON THE MORPHOLOGI G3

PARTICLE SIZE

PARTICLE SHAPE

Introduction

When measuring curved or branched fibers using the technique of image analysis, caliper based measurements of particle length and width do not always provide adequate information for understanding the fiber particle properties.

The Morphologi offers the capabilities to measure the Fiber total length and Fiber mean width which in some cases is far more valuable. Figure 1 shows how the caliper parameters and fiber parameters differ for the particle shown. In addition, from these fiber parameters the Morphologi also calculates the Fiber straightness and Fiber elongation further aiding the understanding of the fiber particle characteristics.

This application note explains how the fiber parameters are calculated and presents the result of a measurement of a fiber sample and compares the caliper and fiber parameter results.

Length (caliper) (µm)	607.10	Fiber total length (µm)	742.59
Width (caliper) (µm)	211.25	Fiber width (µm)	21.86
Elongation (caliper)	0.652	Fiber elongation	0.971

Figure 1: image of a fiber particle and table comparing caliper based parameters and fiber parameters measurements.

Fiber parameters

The Morphologi software calculates four fiber specific parameters: the Fiber total length, Fiber width, Fiber straightness and Fiber elongation

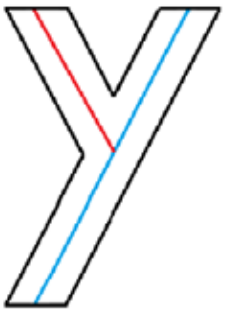
Fiber total length

Initially the fiber image is skeletonized, reducing it to a single pixel line as shown in figure 2. The fiber total length is the length of the skeleton. If the fiber has several branches, then the fiber total length incorporates all of these as illustrated in figure 3.

Fiber width

The Fiber width is the **particle Area/ Fiber total length** which is the mean width along the total length of the fiber (including branches).

Figure 2: skeletonized fiber image



fiber total length = length of blue branch + length of red branch

Figure 3: illustration of fiber total length

Fiber elongation

The Fiber elongation is a measure of how long and thin the fiber is. It is calculated **as 1-(Fiber width/ Fiber total length)**. A totally symmetrical shape like the circle illustrated on the left in figure 4 has a fiber elongation of zero whereas a long thin shape as shown on the right of figure 4 has a fiber elongation of one.

Figure 4: illustration of fiber elongation

Fiber straightness

The Fiber straightness is, as the name suggests, an indication of how straight a fiber is. It is calculated as the **Max distance / Fibre total length**. As figure 5 illustrates a perfectly straight fiber would have a value of one whereas a very wavy fiber would have a value closer to zero.

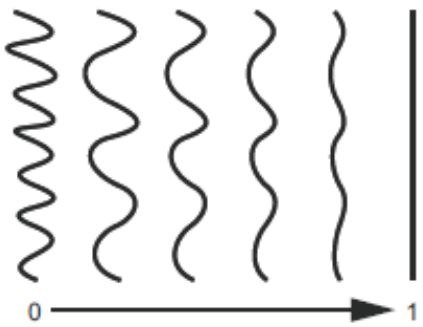


Figure 5: illustration of fiber straightness

Application example

A sample of fiber material (5 mm^3) was dispersed using the Morphologi G3S's integrated Sample Dispersion Unit at 1 bar. It was automatically analyzed with the 2.5x objective with particle stitching enabled. Figure 6 presents an image of a particle which according to caliper measurements is both the longest and the widest in the sample. The Length is 925.28 µm but its Fiber total length is 1357.90 µm, a difference of over 400 µm. Its width is 425.95 µm whereas the Fiber width is only 16.06 µm.

Figure 7 compares the Width (caliper) and the Fiber width distributions. The width distribution suggests there are particles much wider than 100 µm whereas the Fiber width distribution suggests most particles are around 10 µm wide.

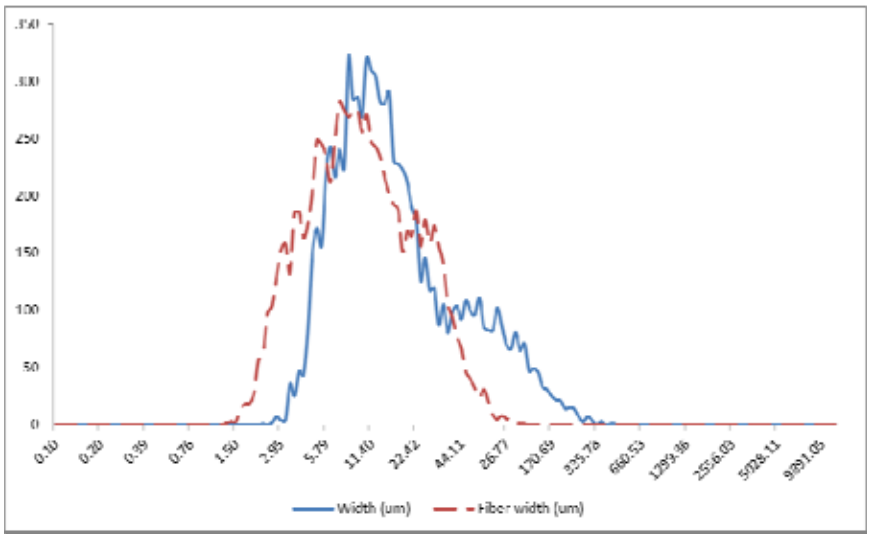
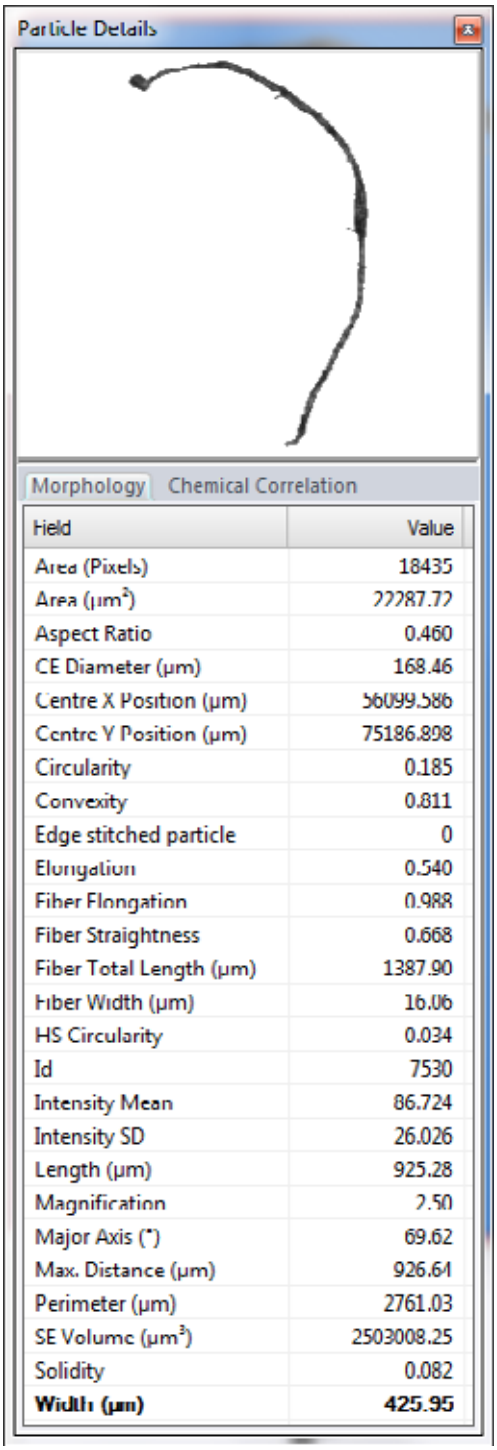


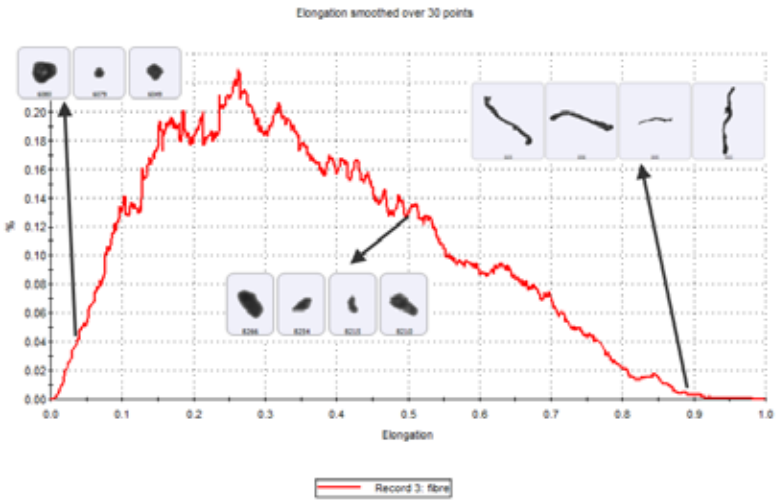
Figure 7: Overlay of Width and Fiber width distributions

The Elongation distribution and the Fiber elongation distribution are also compared in figure 8. Clearly the Fiber elongation provides a more relevant idea of the shape of the fiber particles than the caliper based elongation distribution does.

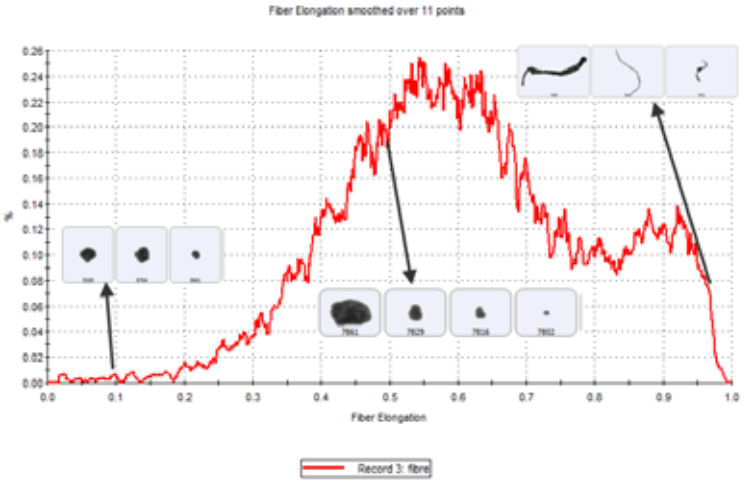


Field	Value
Area (Pixels)	18435
Area (µm²)	22287.72
Aspect Ratio	0.460
CE Diameter (µm)	168.46
Centre X Position (µm)	56099.586
Centre Y Position (µm)	75186.898
Circularity	0.185
Convexity	0.811
Edge stitched particle	0
Elongation	0.540
Fiber Elongation	0.988
Fiber Straightness	0.668
Fiber Total Length (µm)	1387.90
Fiber Width (µm)	16.06
HS Circularity	0.034
Id	7530
Intensity Mean	86.724
Intensity SD	26.026
Length (µm)	925.28
Magnification	2.50
Major Axis (°)	69.62
Max. Distance (µm)	926.64
Perimeter (µm)	2761.03
SE Volume (µm³)	2503008.25
Solidity	0.082
Width (µm)	**425.95**

Figure 6: Particle details



Elongation distribution



Fibre elongation distribution

Figure 8: Comparison of Width with Fiber width distributions and Elongation with Fiber elongation distributions.

Conclusion

The fiber parameters measured by the Morphologi software allow fiber type samples to be measured and reported more appropriately than by using caliper based measurements alone. This allows a deeper understanding of the samples and/or the processes in which they are used.

Malvern Instruments Ltd

Enigma Business Park • Grovewood Road
Malvern • Worcestershire • UK • WR14 1XZ

Tel: +44 (0)1684 892456
Fax: +44 (0)1684 892789

Malvern Instruments Worldwide

Sales and service centers in over 50 countries
for details visit www.malvern.com/contact

more information at www.malvern.com