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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Caliper</th>
<th>Fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>607.10 μm</td>
<td>742.59 μm</td>
</tr>
<tr>
<td>Width</td>
<td>211.25 μm</td>
<td>21.86 μm</td>
</tr>
<tr>
<td>Elongation</td>
<td>0.652</td>
<td>0.971</td>
</tr>
</tbody>
</table>

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).

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.

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.
Application example

A sample of fiber material (5 mm³) 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.

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.
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.