

Particle Analyzer

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Particle analyzer is a MATLAB application that can be used to measure particles dimensions. It has been developed during the work done for the European project *FiberEUse: Large scale demonstration of new circular economy value-chains based on the reuse of end-of-life fiber reinforced composites*.

Glass and carbon fiber reinforced polymer composites (GFRP and CFRP) are increasingly used as structural materials in many manufacturing sectors like transport, constructions and energy due to their better lightweight and corrosion resistance compared to metals. Composite recycling is a challenging task. Although mechanical grinding and pyrolysis reached a quite high TRL, landfilling of end-of-life (EoL) composites is still widespread since no significant added value in the reuse and remanufacturing of composites is demonstrated.

FiberEUse aims at integrating different innovation actions through a holistic approach to enhance profitability of composite recycling and reuse in value-added products.

Considering mechanical recycled composites. Suppliers can provide recycle materials with different properties, consequently, a systematic characterization is needed in order to define some important values that will be helpful in the definition of the process parameter for the remanufacturing. Regardless of the various kinds of fibers (GF, CF, etc.), fibers morphology is useful for the prediction of the mechanical properties of re-manufactured composites.

The fibers analyzed here derive from Siemens Gamesa Renewable Energy S.A. EoL wind turbines, and they were made of an epoxy resin reinforced by continuous GF. Successively, they were shredded and supplied from Consiglio Nazionale di Ricerca – Sistemi e Tecnologie Industriali Intelligenti per il Manifatturiero Avanzato (Stiima-CNR), Italy.

Scanning Electron Microscopy (SEM) micrographs were realized with Cambridge Stereoscan 360 (Cambridge Instrument Company Ltd., UK). Moreover, all the SEM images were obtained using a secondary electron probe and a back scattered electron probe. Sample surfaces for the analysis were previously prepared with a physical vapor deposition (PVD) of gold for 1 min.

As can be seen in Figure 1, fibers with different diameters can be found inside a single recycle batch. Using conventional image processing software it is not possible to automate the measurement process which can be tedious and cannot provide a large dataset for statistical analysis.

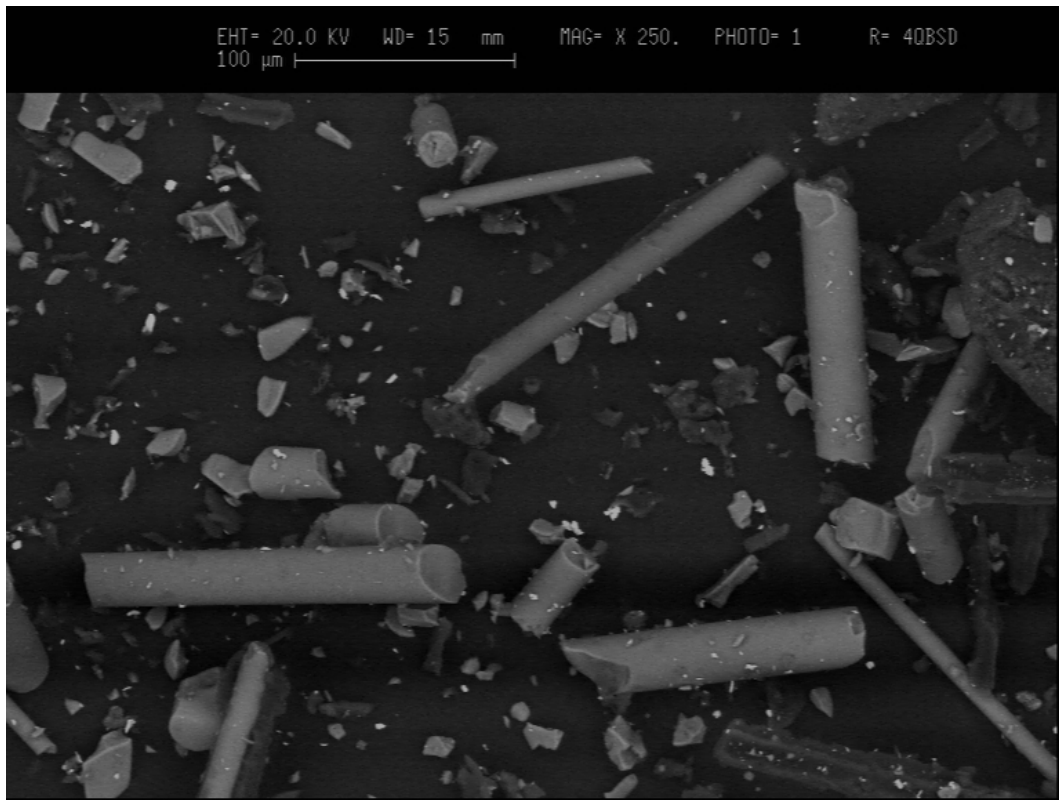


Figure 1 – SEM micrograph: rGF with different diameters.

In order to speed-up the measurement process and to collect a higher number of data, a script has been developed. Its work-flow can be seen in Figure 2.

Firstly, the starting grey-scale image is loaded into the application, and the picture is binarized with a defined threshold after the scale setting (using the marker present in the image). In other words, every image pixel has received a value that goes from 0 (black) to 1 (white): each pixel with a value lower than the threshold becomes black, while every pixel with a value higher or equal to the threshold becomes white. In order to succeed, all the particles to be measured have to be white. If the particles to be measured are black the image color can be complemented to set particles color to white. After, the binary image is refined by eliminating the noise, and the features are isolated. Further refinement is not mandatory, and it can be performed to enhance the precision of the feature edges for more precise measures. By using specific buttons, the features could be added or excluded if the software has got problems in recognizing some of them. Finally, all the selected features can be measured, and the main data (width, length and area) can be stored and exported in a .csv file.

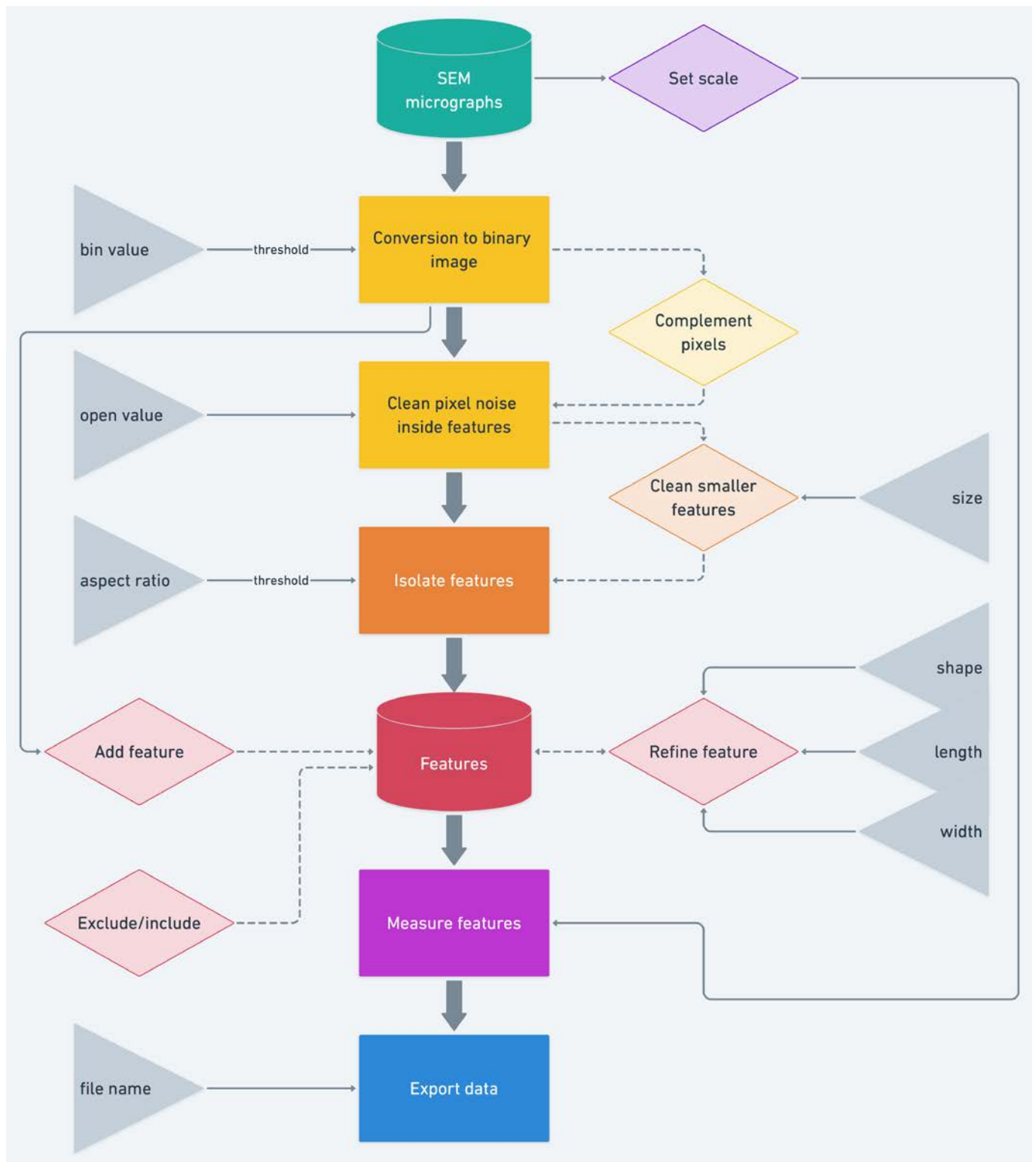


Figure 2 – Flow chart of Particle Analyzer v1.0.

Analyzing different SEM micrograph of the mechanical recycled composite more than 2000 fibers were measured. The distribution of fibers length and diameter is shown in Figure 3.

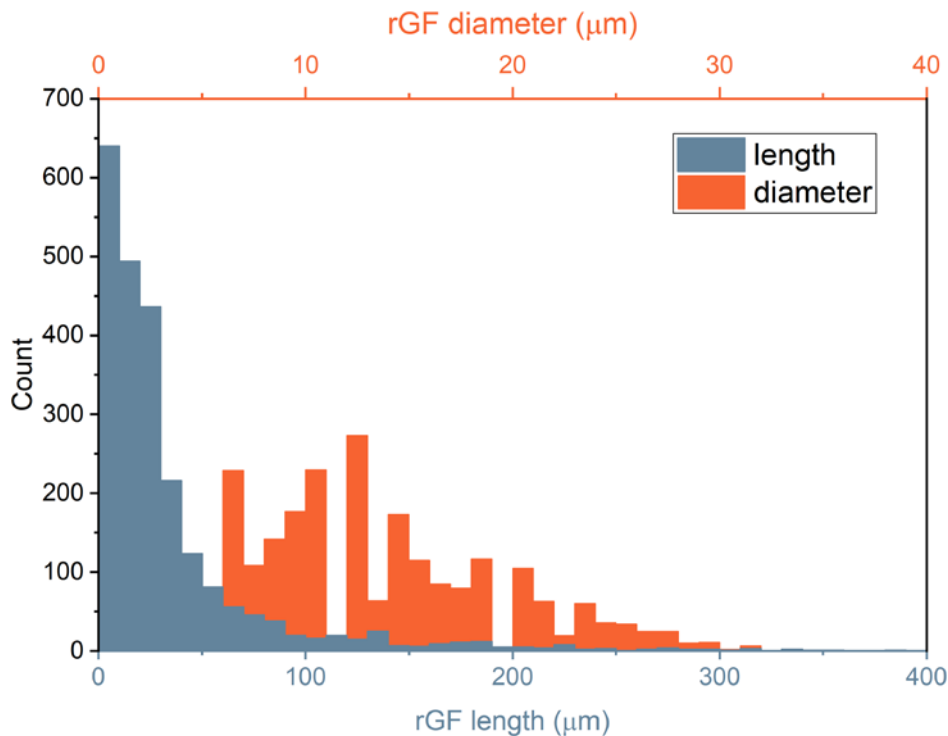


Figure 3 – GAM Fine recycle glass fibers aspect ratio distribution.

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