Multimodal Testing of Single Fibers

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ABSTRACT

Composite materials are increasingly used in building, automotive, and consumer applications. Their performance is influenced by a variety of factors including material organization and the properties of the constituents. Natural fibers used for composite materials (including paper) are discontinuous and in the case of wood fibers, have slenderness ratios which can be less than 100 with diameters on the order of 20 µm. The size and variability of these fibers has historically provided challenges to experimental determination of their micro-mechanical behavior.

The 1990‘s was a time of rapid development of computers (calculations) and computer based technologies (rapid data acquisition and control, digital imaging) which enabled new approaches to fiber testing. A technique to measure tensile properties of discontinuous fibers was developed with improved accuracy through the use of a ball and socket grip assembly, computerized miniature test frame, and low capacity in-line load cell [1]. The system allowed for rapid testing of up to 100 fibers per day. This represented a step change in performance over other approaches and facilitates addressing biological (juvenility, species, etc.) and process derived (acetylation, sizing) questions on fiber quality and micro-mechanical performance [2].

The basic tensile test frame has been combined with a variety of microscopic techniques including laser scanning confocal microscopy (LSCM), environmental scanning electron microscopy (ESEM), and confocal raman microscopy to enable multi-modal investigations of micron scale phenomena of single fibers. The use of digital image correlation (DIC) for detailed fiber surface strain measurements provides the ability to obtain more detailed information on the influence of defects [3]. This powerful tool has been commercially developed over the last 10 years and several vendors currently provide turnkey capabilities. Continued improvements in available instrumentation may allow for the surface (2-D) and volumetric (3-D) evaluation of representative volume elements (e.g. multiple fibers) of composite structures.

References

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