Abstract ICCM 150701-2149

VIRTUAL GEOMETRIC REALIZATION OF WOVEN TEXTILE COMPOSITES

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Abstract text

Background

Several methods for describing meso-mechanical virtual domains of woven textiles exist. Such approaches utilize equations conjured directly from independent textile manufacturing/machining processes. Therefore, extensions beyond cases considered by the originating authors is technically challenging because it requires machining process experience. Consequently, an intuitive, yet simple, method for developing a variety of complex woven textiles is desirable.

Problem Statement

The seminal works in textile modeling (i.e. Peirce) used simple combinations of circular cross-sections, straight line segments, and circular arcs to describe the geometry of plain weaves. Despite their success, many authors contend that it neglects the inherent physics of yarns such as bending rigidity etc. Consequently, robust approaches which address this deficiency, using minimum bending energy principles, have been developed. However, such robust methods require heuristic solution schemes. Nevertheless, it has been shown that augmented versions of these seminal approaches, using non-circular arcs, yield yarn paths that are practically indistinguishable from those produced using alternative robust methods. Thus, this paper proposes a generalized technique, using simple geometric arguments, which considers a variety of complex woven architectures.

Problem Solution

The proposed approach uses a simplistic geometric philosophy similar to Peirce's. Nevertheless, it implements advanced cross-sectional shape functions such as power-elliptical functions etc., capable of describing a plethora of cross-sections. Also, non-circular arcs, adapted from local cross-sectional geometry of yarns, are used to define yarn paths. In addition, more complex woven fabrics such as 3D angle and orthogonal interlocking textiles are considered. Generation of desired woven fabrics is defined by a set of inherent physical geometric arguments which are implemented using numerical techniques. This numerical solution strategy, based on physical arguments, negates the requirement of defining equations restricted to specific textiles, making the proposed technique universally adaptable. The requisite arguments of this approach are implemented in MATLAB using an in-house algorithm, *TextCompGen*. It receives arguments about desired textile architectures, and outputs MATLAB-based plots of the expected geometry alongside a complementary Python-script for automatically re-creating the same geometry in ABAQUS/CAE—a widely-used finite element (FE) pre-processor. The latter feature is included to facilitate subsequent FE analyses, if required.

Results

MATLAB-derived plots of representative virtual domains for woven textiles, derived from *TextCompGen*, are shown in figures 1-2.
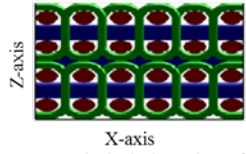
Conclusions

A simple, yet geometrically consistent, method for developing virtual domains of complex 3D woven textiles has been outlined. Its intuitive approach allows seamless adaptability to different classes of woven composites.
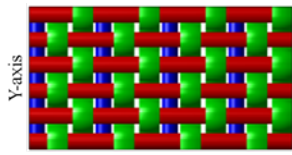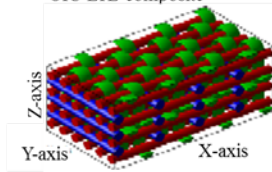
(a) XY principal plane view of OIC-LTL composite
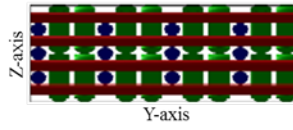
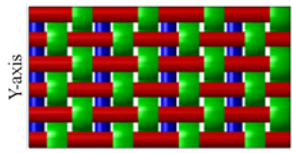**(b) YZ** principal plane view of OIC-LTL composite
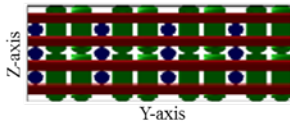
(c) XZ principal plane view of OIC-LTL composite
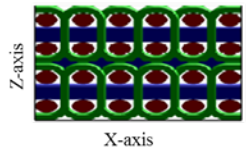
(d) Isometric view of OIC-LTL composite

Image/graph description Different views of a 3D through-the-thickness angle interlock composite (AIC-TTT) generated using TextCompGen.
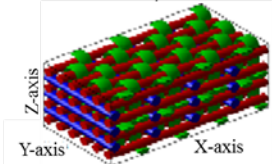

(a) XY principal plane view of OIC-LTL composite

(b) YZ principal plane view of OIC-LTL composite

(c) XZ principal plane view of OIC-LTL composite

(d) Isometric view of OIC-LTL composite

Image/graph description Different views of a 3D layer-to-layer orthogonal interlock composite (OIC-LTL) generated using TextCompGen.

Keywords: Geometry, Meso-mechanical modelling, Virtual Testing, Woven textile composites