Prediction of the Effects of Fibre Architecture on Permeability Using the Stream-Surface Method

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Abstract

Accurate permeability data is critical to successful simulations of the resin flow pattern through a fibre preform. While numerous analytical models and experimental methods exist for determining permeability of fabrics, they do not account for the effects of changes in fibre architecture during the preforming stage or stochastic variations within the fabric itself. The authors have proposed an efficient numerical approach, referred to as the stream-surface method, to predict the permeability which can account for deformation and variations within the preform. This method consists of reducing the complexity of a unit cell mesh by representing 3-dimensional volumes with surfaces while retaining the 3-d attributes for each element on the surface. Flow equations are then solved for the reduced mesh and from the velocity field using Darcy's law to calculate permeability.

A systematic study to validate and investigate the sensitivity of the stream-surface method to various geometric variables of the preform is presented. Simulation results from an in-house solver and a control volume FE flow simulation (LIMS) using the stream-surface method are compared to results from full-detail meshes solved using a commercial CFD package, FLUENT™. The effects of tow fibre volume fraction, tow compression, tow shape, shear angle, stacking sequence, and nesting pattern on overall permeability are discussed. Preliminary results for general textile geometries are also presented.