Spatial distribution of permeability of a 2×2 twill woven fabric composite with hierarchical architecture

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Introduction

Despite intense interest, the contribution of the variability in the internal geometry of textile reinforced polymer composites to permeability of fibrous media is as yet only poorly understood. Ignoring the effect may lead to an overestimation of permeability. In the sense, point-by-point permeability values are required over the fibrous media interval because, (i) both distribution and variation of the permeabilities are needed to develop injection strategies in Liquid Composite Moulding(LCM), (ii) such information is needed as input to simulate local fluid flow. In this study, the effect of randomness in the tow path on the scatter of permeability is investigated. To do so, a stochastic virtual specimen based on the information of an experimentally measured a carbon-epoxy 2/2 twill woven textile composite manufactured by resin transfer moulding(RTM)[1] is developed in the deterministic WiseTex Software by applying the Markov Chain algorithm[2]. Then, FlowTex is used to estimate permeability of each unit cell from the geometry. Nonlinear regression analysis is used to describe the permeability behaviour. In addition, a correlation, describing permeability versus variability in the internal geometry of the fabric, is developed.

Methodology

A virtual textile model was generated in a geometrical format, compatible for WiseTex, for the 2 × 2 twill woven textile spanning a region of 10 × 10 unit cells, representing a ply within a laminate. Knowing the position of unit cells on the virtual geometry allows us to understand whether or not the position from which the unit cell is taken is relevant. In the sense, assuming that unit cells(samples) taken from the virtual geometry(population) are random and independent of each other is not a statistically valid sampling because there may be some degree of correlation between unit cells, i.e there is continuity among unit cells. We regard this as the first major step toward analysing spatial distribution of permeability of unit cells. Then, the virtual geometry was broken down into hundred separate unit cells by a Matlab code. Subsequently, the unit cells were loaded into the WiseTex software and then a geometrical format which is compatible for the FlowTex was generated. The FlowTex was used to compute permeability of each virtual unit cell in both x and y directions. To identify the heterogeneity of the virtual geometry, experimental semivariograms were computed from the permeability data.

Results

Figure 1 shows the histograms of permeability for two directions of x and y, namely K_x and K_y, respectively. The visual inspections reveals that permeability of x direction (Figure 1, left) is not equal to that of y direction (Figure 1, right). In the sense, each direction has a different response to a fluid flow, leading to different flow velocities.

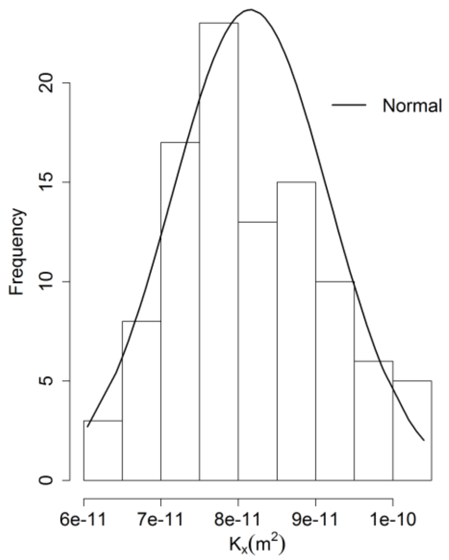

Figure 1: *Histograms of permeability in both x and y directions.*

The Visual inspection (Figure 1) suggests that K_y is two order of magnitude larger than K_x. In the sense the gaps between yarns are larger in y direction compared to x direction. Figure 2 shows spatial distribution of permeability in both x and y directions.

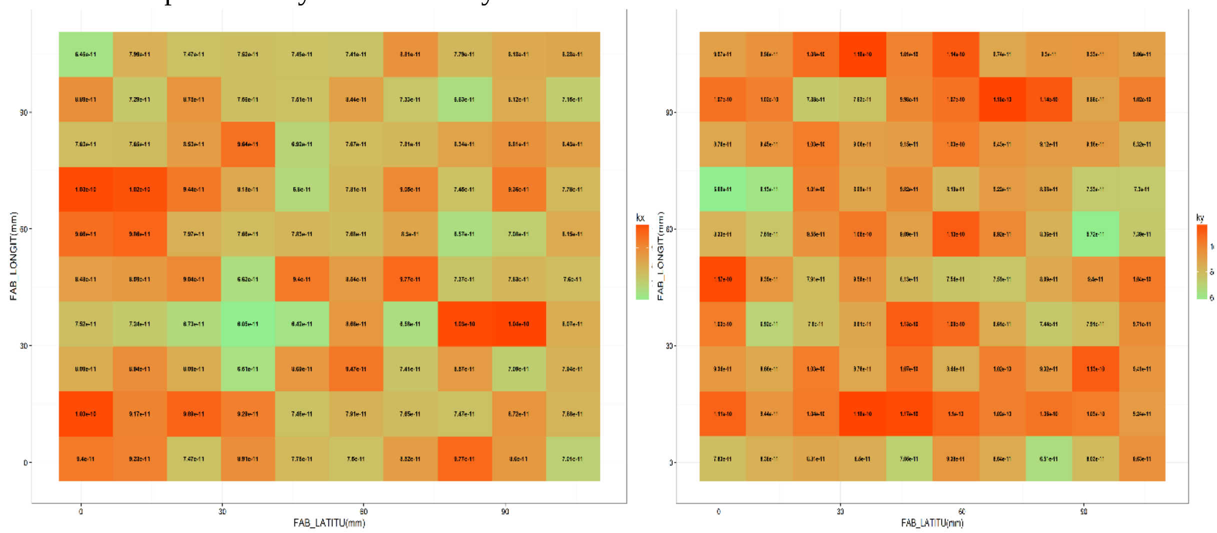

Figure 2: *Spatial distribution of permeability in both x(left) and y(right) directions*

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