DEVELOPMENT OF PERMEABILITY MODELS FOR SATURATED FLUID FLOW ACROSS ARRAYS OF FIBER CLUSTERS

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ABSTRACT

Dual porosity fibrous media are important in a number of applications, ranging from bioreactor design and transport in living systems to composites manufacturing. In the present study we are concerned with the development of predictive models for the hydraulic permeability (Kp) of various arrays of fiber bundles. For this we carry out extensive computations for viscous flow through arrays of fiber bundles using the Boundary Element Method (BEM) implemented on a multi-processor computer. Up to 350 individual filaments, arranged in square or hexagonal packing within bundles, which are also arranged in square of hexagonal packing, are included in each simulation. These are simple but not trivial models for fibrous preforms used in composites manufacturing – dual porosity systems characterized by different inter- and intra-tow porosities. The way these porosities affect the hydraulic permeability of such media is currently unknown and is elucidated through our simulations. Following numerical solution of the governing equations, (Kp) is calculated from the computed flowrate through Darcy’s law and is expressed as function of the inter- and intra-tow porosities (i, t) and of the filament radius (Rf). The thus computed permeabilities are correlated to (i, t) as suggested by earlier studies. Numerical results are also compared to analytical models. The latter form the starting point in the development of a dimensionless correlation for the permeability of such dual porosity media. It is found that the numerically computed permeabilities (over 400 data points) follow that correlation for a wide range of i, t and Rf.
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