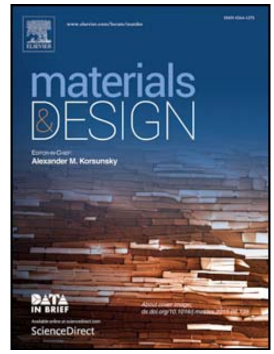
Accepted Manuscript



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PII: S0264-1275(17)30619-6
DOI: doi:10.1016/j.matdes.2017.06.035
Reference: JMADE 3153

To appear in:

Received date: 5 April 2017
Revised date: 12 June 2017
Accepted date: 13 June 2017

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Abstract

Fibrous composite reinforcements with enhanced permeability are of a particular interest for liquid composite molding processes requiring the fibrous preforms to be well impregnated by a viscous polymer. The aim of this work is to study the link between the reinforcement permeability and the geometrical parameters of its architecture, taking into account the internal multi-scale porosity distribution by employing the Brinkman equation. In order to design a reinforcement with the enhanced permeability without degrading mechanical properties of a final composite part, the study is conducted with the condition of fixed and high fiber volume fraction. The Proper Generalized Decomposition method, due to its principle of separation of variables, allowed to efficiently compute the solution of the problem for a range of geometrical parameters at once, as opposed to the classical parametric study. A scale separation criterion for in-plane flow was proposed. It estimates when the microscopic intra-yarn flow can be neglected compared to the mesoscopic inter-yarn flow. The major contributing parameters to the enhancement of both the in-plane and through-thickness permeabilities were identified. Principles established in this study were applied to the design of quasi-unidirectional non-crimp fabrics, where the permeability enhancement was evidenced.

Keywords: enhanced permeability, design, fibrous reinforcement, multi-scale structure, Brinkman equation, Proper Generalized Decomposition

1 Introduction

Fabrics used as reinforcement in structural composites are usually made of woven or stitched fiber tows. Fiber tows can be viewed as clusters of fibers, and pores between tows – as tortuous channels between them. As a consequence, fabrics are a dual-scale porous medium (two-phase fibrous medium), i.e. the porosity structure composed of mesoscopic pores between fiber tows and microscopic pores between fibers inside each tow. The meso-pores offer lower flow resistance compared to the fiber tow with higher flow resistance. It is worth noting that meso-channels are always connected to micro-channels, meaning that there is no dead-end for the fluid. The ability of the fibrous medium to transmit fluid is a crucial property for Liquid Composite Molding (LCM) processes that involve infiltration of a dry fibrous preform with a liquid polymeric resin under low pressure.