HAL
open science

Micro-scale modeling of resin flow by BEM-Permeability computation

M.Q. Thai, Fabrice Schmidt, Gilles Dusserre, Arthur Cantarel, L. Silva

To cite this version:

M.Q. Thai, Fabrice Schmidt, Gilles Dusserre, Arthur Cantarel, L. Silva. Micro-scale modeling of resin flow by BEM- Permeability computation. International conference on COmputational methods in Manufacturing Processes, 2014, Saint-Etienne, France. hal-02053410

HAL Id: hal-02053410

https://hal.science/hal-02053410v1

Submitted on 6 Mar 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Micro-scale modeling of resin flow by BEM-Permeability computation

M.-Q. Thai [a*], F. Schmidt [a],G. Dusserre [a], A. Cantarel [b], L. Silva [c]

[a] Mines Albi, Albi – France

[b] IUT-Tarbes, Tarbes – France

[c] Mines Paris Tech, Sophia Antipolis – France

[*]corresponding author

Keywords: Permeability, Boundary elements method, Level Set, Simulation.

1. Introductions

In LCM (Liquid Composite Molding), the resin flow is characterized by a strong geometric complexity where a fibrous reinforcement has been placed. The preform usually has several layers organized into yarns, which are themselves composed of several thousand of fibers. Permeability is one of the most important parameter for modeling flow. Its value is directly dependent on the fibrous media architecture. Our purpose is developing a numerical method to determine the permeability from real microstructures which is difficult to obtain experimentally. In this paper, we have developed 2D and 3D BEM models capable of solving flow problem at microscopic scale in a saturated and an unsaturated media, and using this result, the permeability can be also computed. The model is validated by comparison with solution analytical.

2. Permeability computation

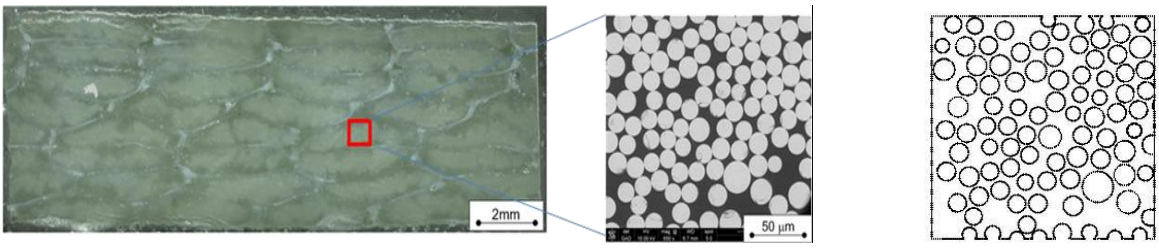
The governing equations for the flow of an incompressible Newtonian viscous fluid are the Stokes equation:

$$\begin{cases} \mu \Delta v = \nabla p & in\ \Omega \\ \nabla . v = 0 & in\ \Omega \end{cases} \tag{1}$$

Which v the fluid velocity, p the pressure, μ the viscosity. These equations are solved using boundary element method based on elastostatics Green's function [1]. The velocity and pressure obtained are used to determine the permeability and to simulate the advance front resin using level set method.

Permeability computation in 2D case

In this section is presented the determination of permeability in composite reinforcement from a real microstructure obtained by image processing. Once a boundary mesh is defined (figure 1c), we can carried out BEM method developed by PhD student R. Gantois in two-dimensional [2] in order to compute permeability.



a) Mesoscopic scale (tows) b) Micro-scale c) Boundary mesh

Figure 1: Image processing

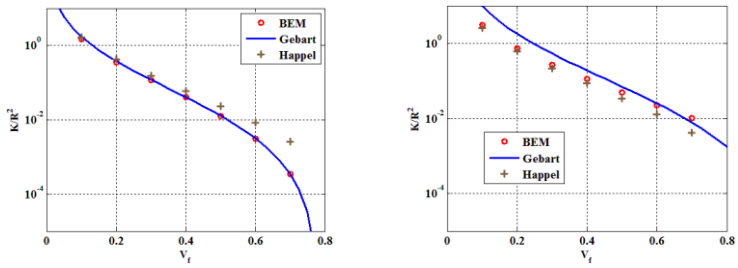
The Advanced Front resin is treated thanks to a Level Set approach. The boundary mesh generation is performed by algorithms Marching Triangles. Once the velocity and pressure have been computed at the end of the simulation, and then the transverse permeability can be determined using Darcy's law yield. Permeability results are given in the table 1. It is noticed that once permeability at microscale from the real microstructure is obtained, the permeability at mesoscale can be determined by multiscale homogenizations method.

Table 1: Permeability results

Case	V_f	$K_x(m^2)$	$K_y(m^2)$
Saturated	0.47	$6.51.10^{-13}$	$8.80.10^{-13}$

Permeability computation in 3D case

BEM's method is once again appliqued to solve the Stokes equation in 3D case. The real difference between this case and the case above is the formula of fundamental solution and how to evaluate its integral. Our numerical method is validated by comparing both transverse and longitudinal permeability with those given by analytical model [3]. The result showed a fair agreement between analytical and computed permeabilities (figure 3).



a) b)

Figure 3: Comparison of transverse (a) and longitudinal permeability (b)

Permeability of composite reinforcement is studied in this work. BEM method is appliqued to simulate the microflow in the structure of reinforcement for two and three-dimensional geometries. The determination of permeability reveals a good accordance with analytical model. In future work, this method will be also applied to take into account the porosity and the wetting of the fiber surface.

3. Bibliography

[1] Brebbia, C.A., and Dominguez J. *Boundary elements: an introductory course*, Computational Mechanics Publications, 2nd edition, 1992.

[2] Gantois, R and al. *BEM-based models to simulate the resin flow at macroscale and microscale in LCM processes.* 1235-1244, Polymer Composites,2013.

[3] Gebart, B.R. *Permeability of unidirectional reinforcements for RTM.* 1100-1133, Journal of Composite Materials, 1992.