

INFLUENCE OF INTRA-YARN PERMEABILITY ON MESO-SCALE PERMEABILITY OF PLAIN WEAVE AND 3D FABRICS

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Introduction:

- An understanding of mesoscale permeability of complex porous preforms is of particular interest to achieve efficient and cost-effective resin impregnation of liquid composite moulding (LCM) [1,2]
- Typically, the preform consists of an arrangement of yarns with spacing in the order of *mm* wherein each yarn consists of thousands of filaments with spacing in the order of μm . (Figure 1)
- The fluid flow during infusion exchanges the mass between the intra and inter-yarn channels, meaning there is no dead-end of flow between



the mesopores in the inter-yarn space and the micropore in the yarn [3].

Objective:

- Identify the influence of intra-yarn permeability on the mesoscale permeability with weft, warp yarn spacing on the plain weave and 3D weave with binder yarn
- Pareto-optimal pattern of 3D weave fabric varying warp, weft, and binder spacing, pattern and number of layers using multi-objective • optimisation Non-dominated Shorting Genetic Algorithm (NSGA)-II [4].

Figure 1: 3D woven preform with binder yarn (from Optimise project University of Manchester, UK)



Results:

Table 1. Mesoscale permeability of an orthogonal weave

Preform type	Permeability [m2]	Solid yarn	Porous yarn porosity (ϕ)
2x2 warp symmetric weaveImage: Colspan="2">Image: Colspan="2"Image: Colspan="2" Image: Colspan="	Kxx / 10 ⁻¹⁰	3.7051	3.7790 (φ = 0.22) 3.7790 (φ = 0.12)
3D preform (2warp, 3weft, 1binder)	Kxx / 10 ⁻¹⁰	6.66	8.70 ($\phi = 0.22$) 8.70 ($\phi = 0.12$)
	Куу / 10 ⁻¹⁰	9.99	10.02 ($\phi = 0.22$) 10.01 ($\phi = 0.12$)
i minimum, minimum, minimum, minimum, i Mariana	Kzz / 10 ⁻¹⁰	2.94	2.68 ($\boldsymbol{\varphi} = 0.22$) 2.67 ($\boldsymbol{\varphi} = 0.12$)



Figure 3: (a) Pareto-optimal generation of in-plane permeability Kxx with Vf considering porous yarn and (b) Kyy vs Vf with warp spacing using porous yarn.

Conclusions:

- Meso-scale permeability predictions based on porous yarns differed from solid yarns by up to 20%.
- Pareto-optimal design space of warp, weft and binder follows the Kozeny-Carman model.





Kyy increases as the spacing between warp yarn decreases.

It is necessary to incorporate the permeability of porous yarn in meso-scale permeability prediction.

References:

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