MULTI-SCALE MODELLING OF COMBINED DETERMINISTIC AND STOCHASTIC FABRIC NON-UNIFORMITY FOR REALISTIC RESIN INJECTION SIMULATION

A. Endruweit*, X. Zeng, A.C. Long

Faculty of Engineering – Division of Materials, Mechanics & Structures,
University of Nottingham, University Park, Nottingham, NG7 2RD, U.K.
**Corresponding author's e-mail: andreas.endruweit@nottingham.ac.uk*

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Introduction

In Liquid Composite Moulding, non-uniformity of reinforcement fabrics, i.e. local variability in structure and permeability, results in irregular resin flow patterns and variable mould fill times, which makes the outcome of resin injections in actual components hard to predict and may cause formation of dry spots.

Deterministic fabric non-uniformity is related to shear during forming, which depends on the initial conditions of the forming process and affects the local yarn arrangement. Stochastic non-uniformity refers to random effects determining the reinforcement structure locally. Both are affected by the fabric architecture.

Stochastic modelling

Random effects at different scales are considered in stochastic modelling of local fabric properties (Figure 1). Defined realistic levels of randomness are derived from experimentally observed variability.

In non-uniform bi-directional reinforcements made from continuous yarns, local fabric permeabilities can be estimated based on numerical analysis of flow through local yarn arrangements (Figure 2).

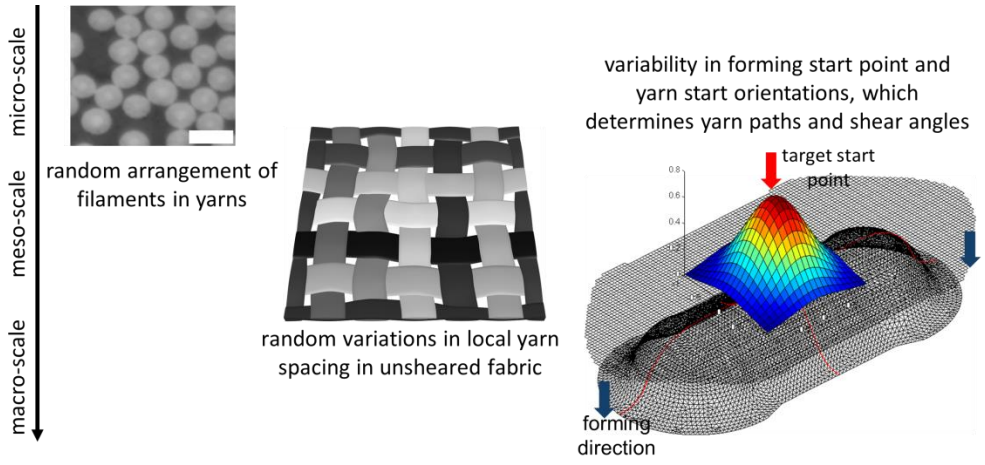

Figure 1: *Stochastic effects modelled at different scales.*

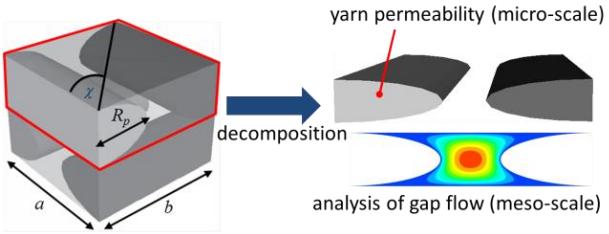

Figure 2: Fabric permeability can be estimated from yarn permeability and analysis of gap flow in abstracted fabric unit cell (example: non-crimp fabric).

Implementation

Combined deterministic and stochastic effects were incorporated in fabric forming simulations. Non-uniform permeability fields were calculated from the predicted local yarn arrangements. Local permeabilities were used as input for subsequent resin injection simulations. In the predicted typical resin injection scenarios (Figure 3), areas with the longest fill time (indicated in red) are most susceptible to dry spot formation.

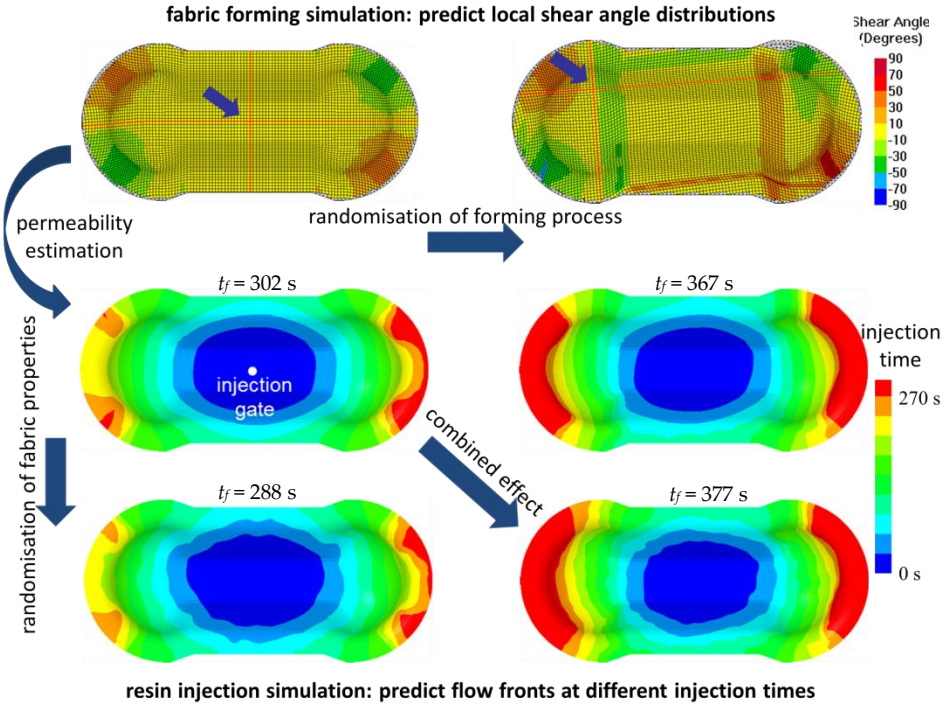

Figure 3: *Combined effect of deterministic and stochastic fabric non-uniformity on results of resin injection; example: double-dome geometry; typical total fill times, t_f, are also given.*

Conclusions

Realistic modelling of deterministic and stochastic fabric properties indicates how fabric non-uniformity affects flow front shapes and times for complete impregnation of reinforcements. A more detailed correlation between predicted flow patterns and defect formation still needs to be established.

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