Meso- and macro scale permeability simulations on the Pan cluster

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Introduction: Composite material



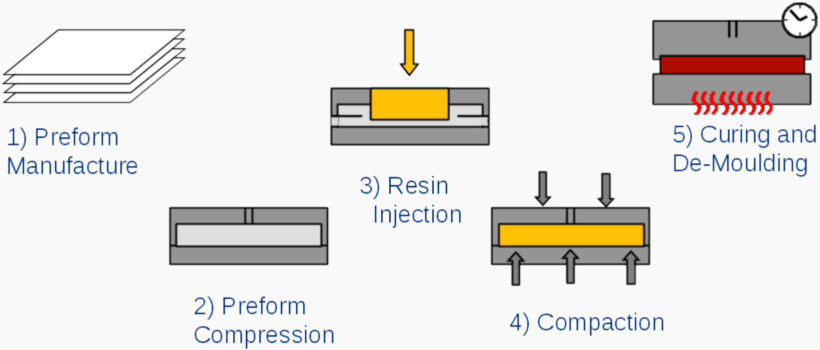

Composite material

Two or more constituent materials with significantly different physical or chemical properties, that when combined to produce a material with characteristics different from the individual components:

1. Reinforcement e.g. carbon fiber;
2. Matrix e.g. hardened resin.

Production process

Liquid Composite Moulding



Production process: Simulation

Outputs of simulations are used to optimise the process by selecting:

- Injection times
- Injection locations
- Vent locations
- Injection pressures
- Press size
- Energy consumption

Permeability

Definition

Permeability characterises the ease with which a fluid can flow through the reinforcement

Permeability depends on:

- Fibre volume fraction
- Compaction applied
- Stitching
- Reinforcement architecture
- Laminate structure and nesting
- Geometric variability

Textile Modelling:

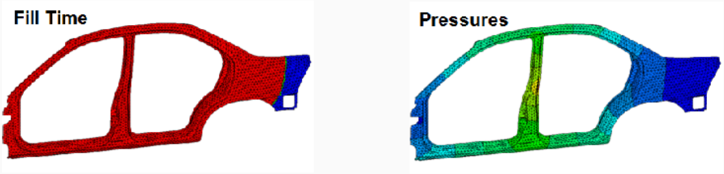
- Automatic
- Repeatable
- Complex fibre architecture
- Computationally Intensive
- Requires validation

Experiments:

- Complex fibre architecture
- Capture nesting
- Time consuming – User intensive
- Difficult to perform accurately

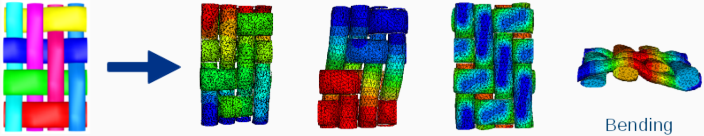
Meso vs. Macro scale

MACRO



Walbran, A., SimLCM 2011

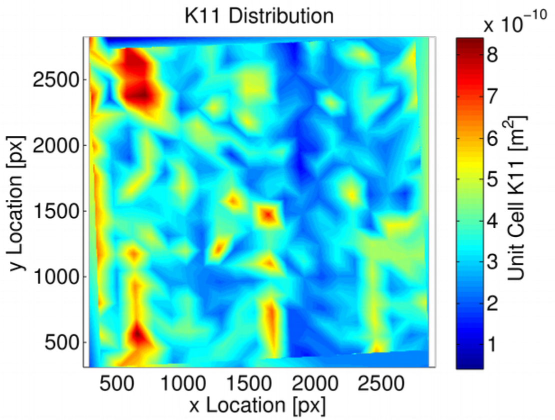
MESO



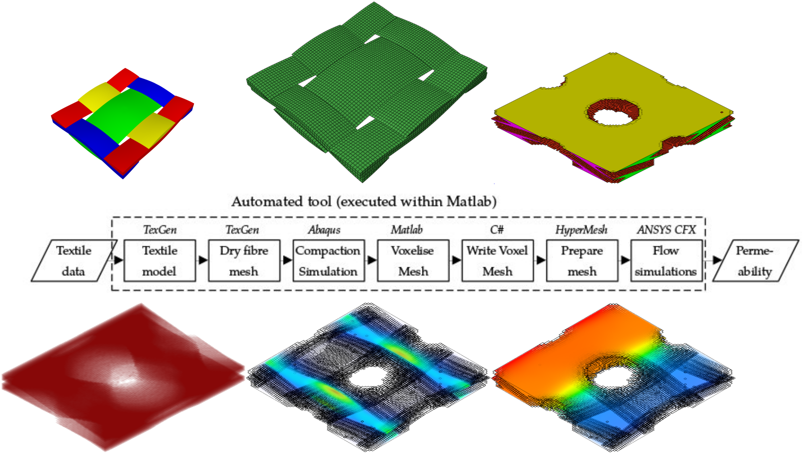
Lin, H. TexGen 2011

Meso and Macro

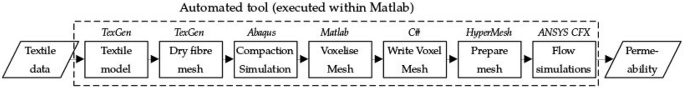
- A full CFD simulation on a macro-scale model is almost impossible and would take too much resources.
- Solution: (many) Meso-scale simulations that provide input for an easier macro-simulation.



6 different programs



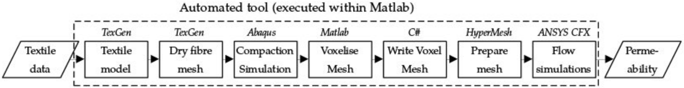
6 different programs



To make the tool work on Pan, following steps were undertaken:

1. Install TexGen and compile the C# software. Abaqus, Matlab, ANSYS and Hypermesh are available modules on Pan.
2. Define the correct command lines for all the software. In case of HyperMesh, this was only able to be completed with help from the supplier.
3. Adapt the scripts and input files for a Linux system, including changing hard coded paths.
4. Split up the main script and provide a Slurm scheduler input file for every step. This is important for the macro-scale simulation (see further).
5. Write a script that submits all Slurm files as a chain job.

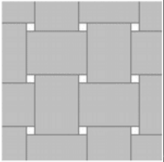
6 different programs

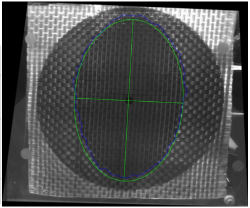


The different steps have different requirements:

- TexGen, Hypermesh and C# only run serial.
- Abaqus and ANSYS can run parallel.
- Solution: 6 different SLURM jobs with dependencies.

Experiment

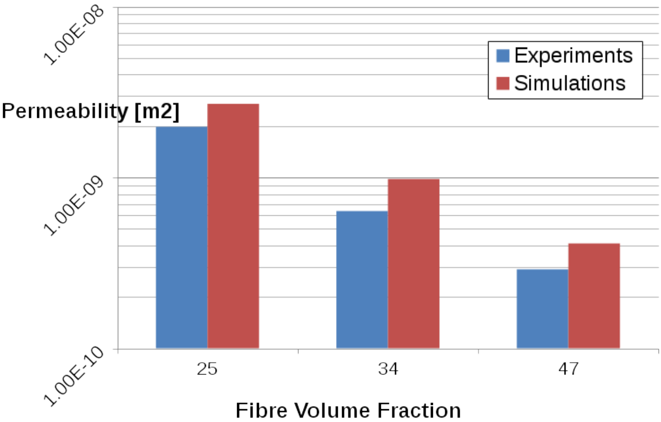




2D in plance single layer

- Different thicknesses: 1.2, 0.9, 0.7 mm
- Different volume fractions:0.25, 0.34, 0.47 %

Results



1.00E-08
1.00E-09
1.00E-10
Permeability [m2]
Experiments
Simulations
25
34
47
Fibre Volume Fraction