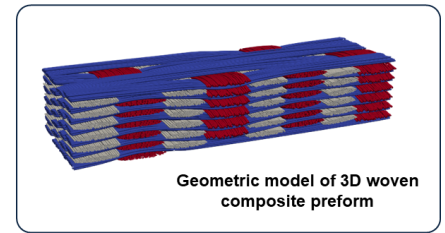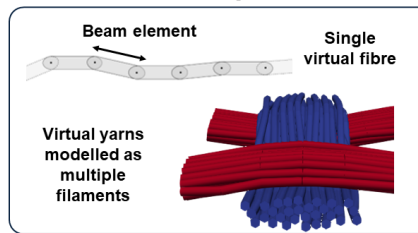# Rapid Braid Manufacture Simulations Using SimTex

Jordan Jones, Adam Thompson, Ric Sun, Stephen Hallett

Braiding is a well-established technique used to manufacture composite ropes and hollow components. Advantages include high production rates and the possibility of mechanical performance tailoring through modification of the braid pattern and angle. However, the dynamic nature of the braiding process results in complex yarn interactions that can induce significant variability to braid formation and manufacture quality. Virtual braiding using numerical methods offers a solution for discovering more ideal processing parameters that improve final part quality. This work uses SimTex, a custom Multi-filament Digital Yarn solver developed at the BCI, for enhanced braid manufacture simulations. Bespoke contact formulations and novel functionality, such as the 'virtual bobbin' concept, provide the potential for:

(1) Efficient intermediate process models for virtual manufacture of complex industrial-level braided parts.
(2) Higher resolution approaches that move beyond state-of-the-art alternatives to also capture thickness variability and characterise local braid permeability – important parameters for determining part quality and mechanical performance.
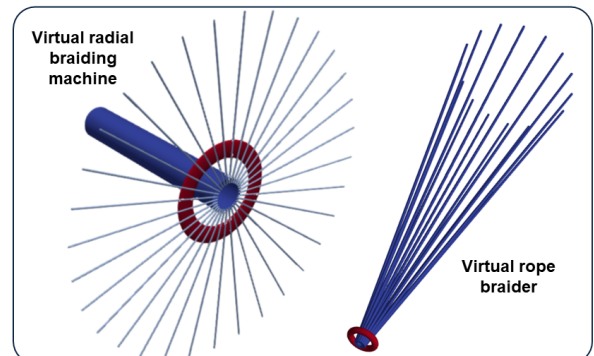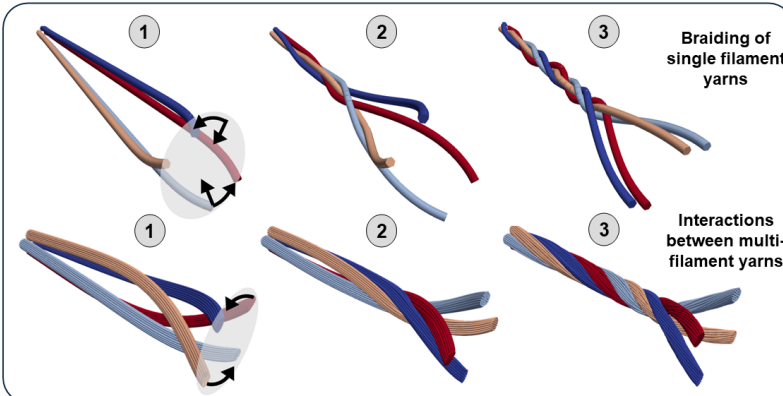
Simulation of **Tex**tile Composites - **SimTex**

- SimTex has been employed extensively at the BCI to produce accurate geometric representations of 2D and 3D woven textile architectures.

- Multi-filament method used, in which each yarn is modelled as "bundle" of virtual fibres and each virtual fibre represented as an interconnected chain of short beam elements.

Beam element

Single virtual fibre

Virtual yarns modelled as multiple filaments

Geometric model of 3D woven composite preform

Virtual Braid Manufacture

- Work aims to develop SimTex for virtual braiding simulations. Expect same benefits observed with fabric simulations, i.e. faster analysis times compared with commercial alternatives, which allows for the study of more complex cases and freedom to operate at higher fidelity.

- First steps to implement boundary conditions that represent kinematics of the braiding process – i.e. movement of yarn carriers in the spool plane.

Braiding of single filament yarns

Interactions between multi-filament yarns

Virtual radial braiding machine

Virtual rope braider

- Future work is to test capabilities with full-scale braiding simulations, with benchmarking computational time and model accuracy against commercial alternatives.

- Also introduce 'virtual bobbins' for on-the-fly population of yarn length. Maintains constant spool dimensions and improves yarn tension control and model stability.

Virtual bobbin source position

Yarn pull-through rate adjustable and coupled with yarn tension

(1) Initial yarn length (blue) defined at the start of the analysis.
(2) Take-up of the yarn during braiding displaces yarn end that is initiated at bobbin (yarn carrier) position.
(3) A virtual bobbin allows new beam elements (grey), i.e. yarn length, to be extruded from this geometric position (orange).
(4) Process models yarn length being pulled from physical bobbins during actual manufacture.