Overview

Macro-scale Forming

• Dissemination
• Collaboration
• Industrialisation

Software: SimTex

• Developments
• Dissemination

What's Next?

Composites: MadeFaster
Macro-Scale Forming
DefGen Outputs

Modelling defect formation in textiles during the double diaphragm forming process
Adam J. Thompson, Jonathan P-H Belnoue, Stephen R. Hallett
Bristol Composite Institute (ACCI), University of Bristol, Queen’s Building, University Walk, Bristol, BS8 1TR, UK

Numerical modelling of compaction induced defects in thick 2D textile composites
Bristol Composite Institute (ACCI), University of Bristol, Queen’s Building, University Walk, Bristol BS8 1TR, UK
HypoDrape

User material subroutine for Abaqus to capture the kinematic behaviour of fibres during forming.

Used as the foundation for a number of projects within SIMPROCs

Released in 2020 via BCI process modelling Github page:

- 30 subscribers worldwide
- Currently in use by Airbus and NCC
- Led to 2 successful international collaborations
Collab. #1
Rashidi A, Milani A.S, University British Colombia

Extension to pre-impregnated textiles including:

- inter-ply shear behaviour
- consolidation behaviour

Resulting model was able to capture:

- consolidation induced wrinkles over single curvatures
- evolution of wrinkles during forming through to consolidation in large ply stacks

The collaboration lead to a publication
Collab. #2

Broberg P, Bak B.L.V, Lindgaard E, Aalborg University

Extend model to include:

- nonlinear bending stiffness
- inter-ply cohesion/tack

Resulting model was able to predict wrinkle positions and their representative size

Productive collaboration which lead to enhanced capability
Forming of NCFs

Williams L, Airbus, BCI

Textile constitutive models are typically adopted for modelling NCFs but unable to capture intra-ply slippage present in these materials.

Introduction of new contact model which captures the intra-ply slip behaviour present within an NCF.

Contact model includes a no separation condition imposed by stitch yarn, while permitting fibre-aligned tow sliding.
Industrialisation

Williams L, Airbus, BCI

Constructing work flows to simplify the model build, run and post-processing of results.

Developing methods to stabilise simulations and make their ease of use akin to kinematic methods.

Allows users to see the formability of a part and identify possible regions of concern early in design stage before full definition of manufacturing process.
Process Optimisation

Chen S, Alan Turin Institute, BCI

Rapid prediction tools required to explore variability in manufacturing processes and optimise manufacturing parameters.

Training a Gaussian Process to emulate computationally intensive models is a promising solution.

Once trained the Gaussian Process emulator is used for the optimisation.
SimTex
What is SimTex?

Bespoke finite element solver developed for creating realistic virtual textile architectures

Focuses on efficient resolution of contact between spherocylindrical particles

Virtual fibres represented as chains of these particles

Arrays of virtual fibres used to represent fibrous tows
What is SimTex?

Textile unit cells built from basic textile design information:

- Weave architecture
- Number fibres per tow
- Fibre diameter

Tension applied to virtual fibres, simulating tension during weaving process.

Resulting model captures realistic fibre paths and cross sectional shapes
SimTex PrePost

Primary purpose of SimTex is to provide realistic geometries for mechanical performance modelling.

SimTex PrePost provides functionality to build and run mechanical models and perform numerical homogenisation.

Released to Rolls Royce Plc and is now being actively used for the design and analysis of jet engine components.
Why SimTex?

Comparisons with commercial FE codes showed SimTex to achieve the same result in ~ one seventh of the time.

Improvements down to more robust and efficient contact algorithm.

Removing constraints of working in COTS tools allowed more novel ideas to be implemented which also improved speed ups.

Further speed ups achieved by working with RSE’s to refactor and optimise code base.

<table>
<thead>
<tr>
<th>SimTex</th>
<th>LS-Dyna</th>
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<tbody>
<tr>
<td>10 hours, 1CPU.</td>
<td>72 hours (3 days) , 1CPU</td>
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<tr>
<td>Refactor + optimisations</td>
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<td>5.5 hours, 1CPU</td>
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Near-net shape

Integration of final component features into internal architecture:
- Ply drops
- Bifurcations

Significant challenge for modelling as size and complexity of textiles increases

Introduced methods to deal with complex tightly woven features and for achieving final part shape without unwanted artefacts
Near-net shape
Braiding

Introduced beam to surface contact to capture tow- mandrel interaction

Virtual bobbins – elements pulled from source under a given tension to simulate tow pulled off the bobbin

Same technology applicable to other manufacturing process such as explicit modelling of weaving and filament winding
What’s next?
Composites: MadeFaster

Rapid, physics-based simulation tools for composite manufacture

Providing simulation capability to capture variability in process and material.

Extending SimTex to consider a greater range of manufacturing processes.

Use dimensional reduction techniques to reduce complexity while retain predictive capability.

Result: ability to capture statistical spread of likely outcomes instead of a single deterministic result.
Credits

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Yi Wang
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Thank You

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