NATIONAL COMPOSITES CENTRE

CATAPULT High Value Manufacturing

Thermoplastic Composite Overmoulding Warpage

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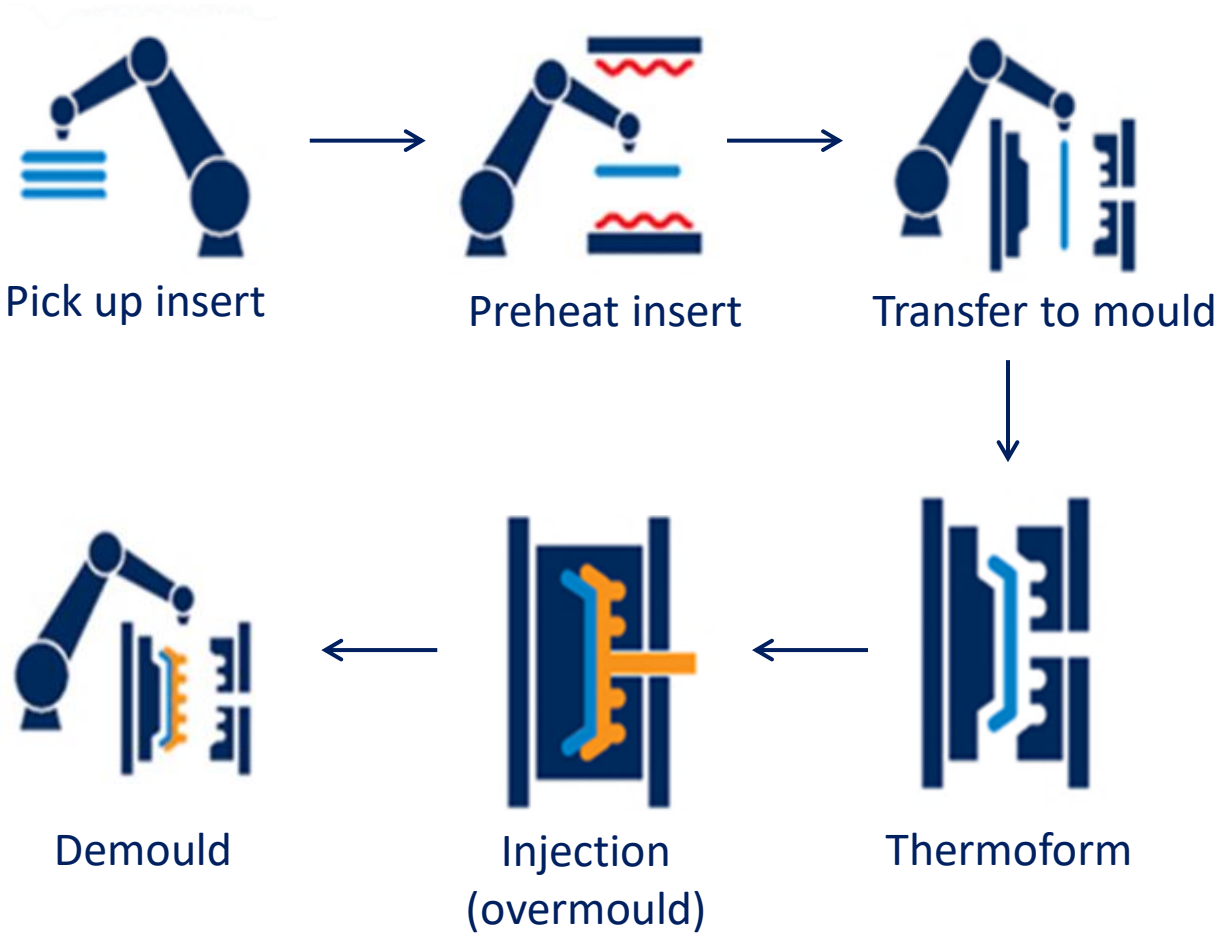
Introduction

- Thermoplastic Composite Overmoulding
- Thermoplastic Composite Overmoulding at the National Composites Centre (NCC)
- Current Challenges and Aims of the Research
- Coupon Panel Geometry
- Process Simulation
- Warpage Simulation
- Validation
- Discussion
- Future Work

Thermoplastic Composite Overmoulding

- The combination of thermoforming and injection moulding
- Can be a single or dual step process



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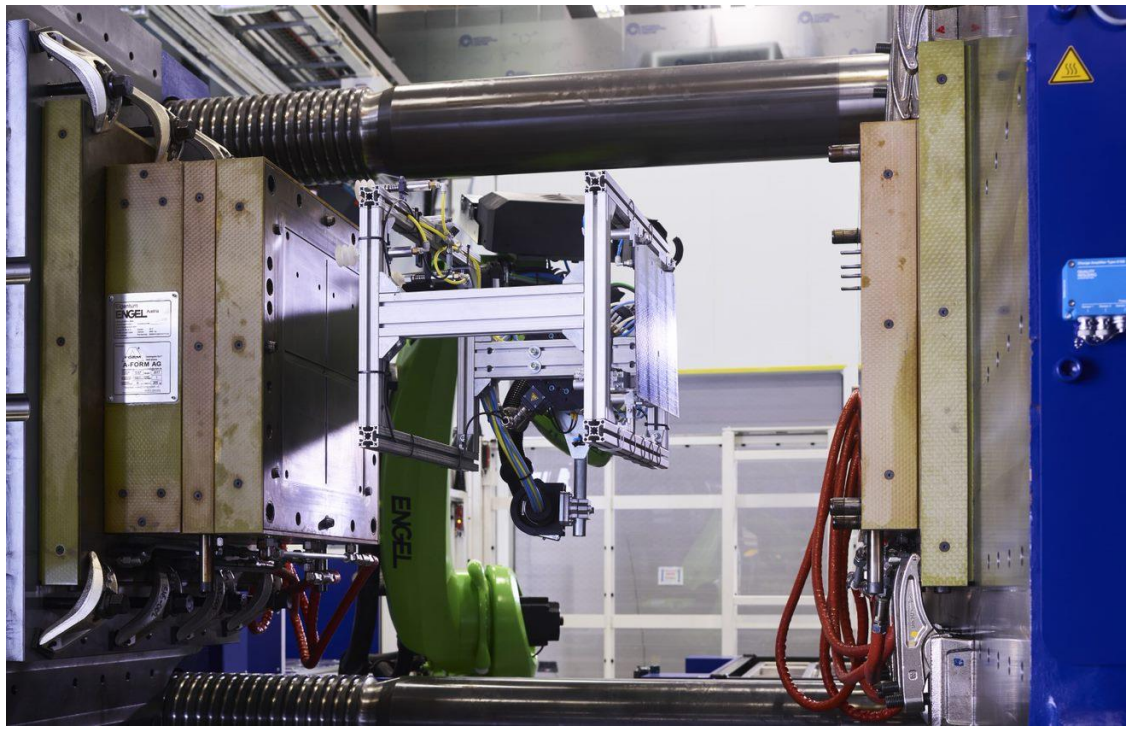
Overmoulding at the NCC



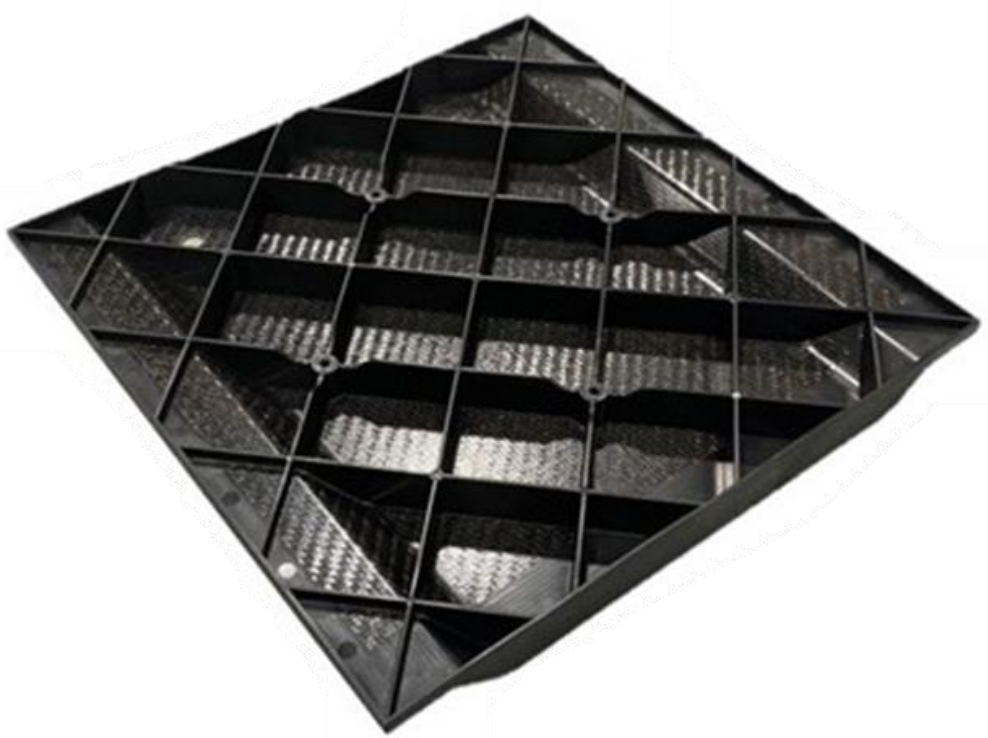
- Fully automated Engel overmoulding cell
- 1700 t Engel Duo press with 1.8 x 1.4 m usable platen area
- Small and large injection units depending on required shot volume (135-6450 cm^3)

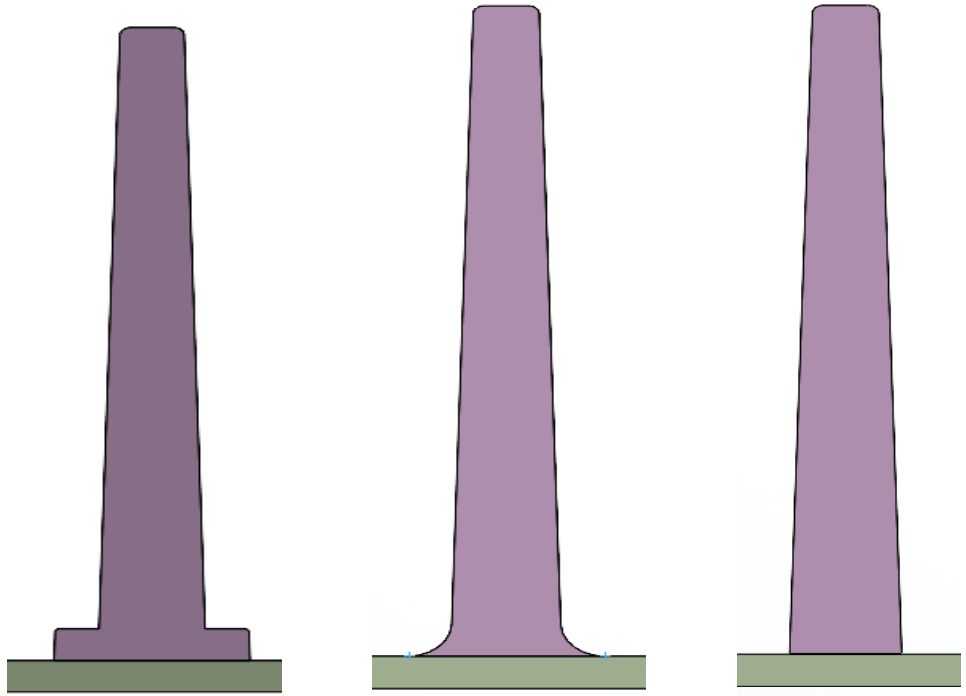
Challenges and Aim

- Thermoplastic overmoulding is a high-rate manufacturing process, which offers the potential to cost effectively meet the increasing rate requirements of the aerospace industry and weight reduction requirements in the automotive industry
- There is currently a low confidence in using overmoulded components in structural applications due to the lack of validated predictive models, experimental and manufacturing data

- The Aim of this research is to generate a validated predictive model for the warpage and mechanical behaviour of thermoplastic overmoulded composite parts

Coupon Panel Geometry

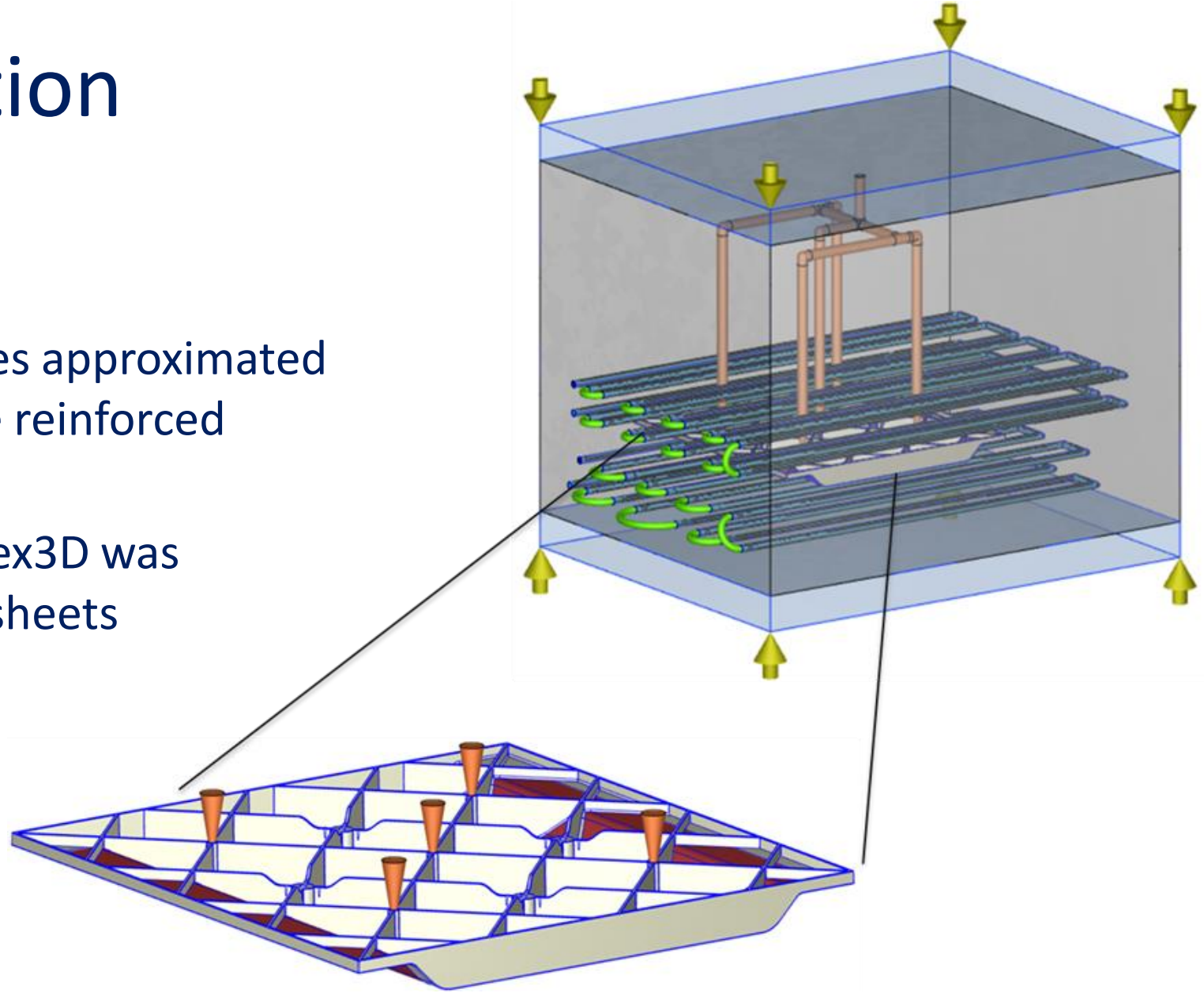




- Organosheet is a woven glass fibre PA6 material
- Injection moulding compound is a 30% glass fibre PA6
- Coupon panel is 540 x 540 mm
- Ribs are 40 mm in height
- Lattice structure includes three different rib foot geometries

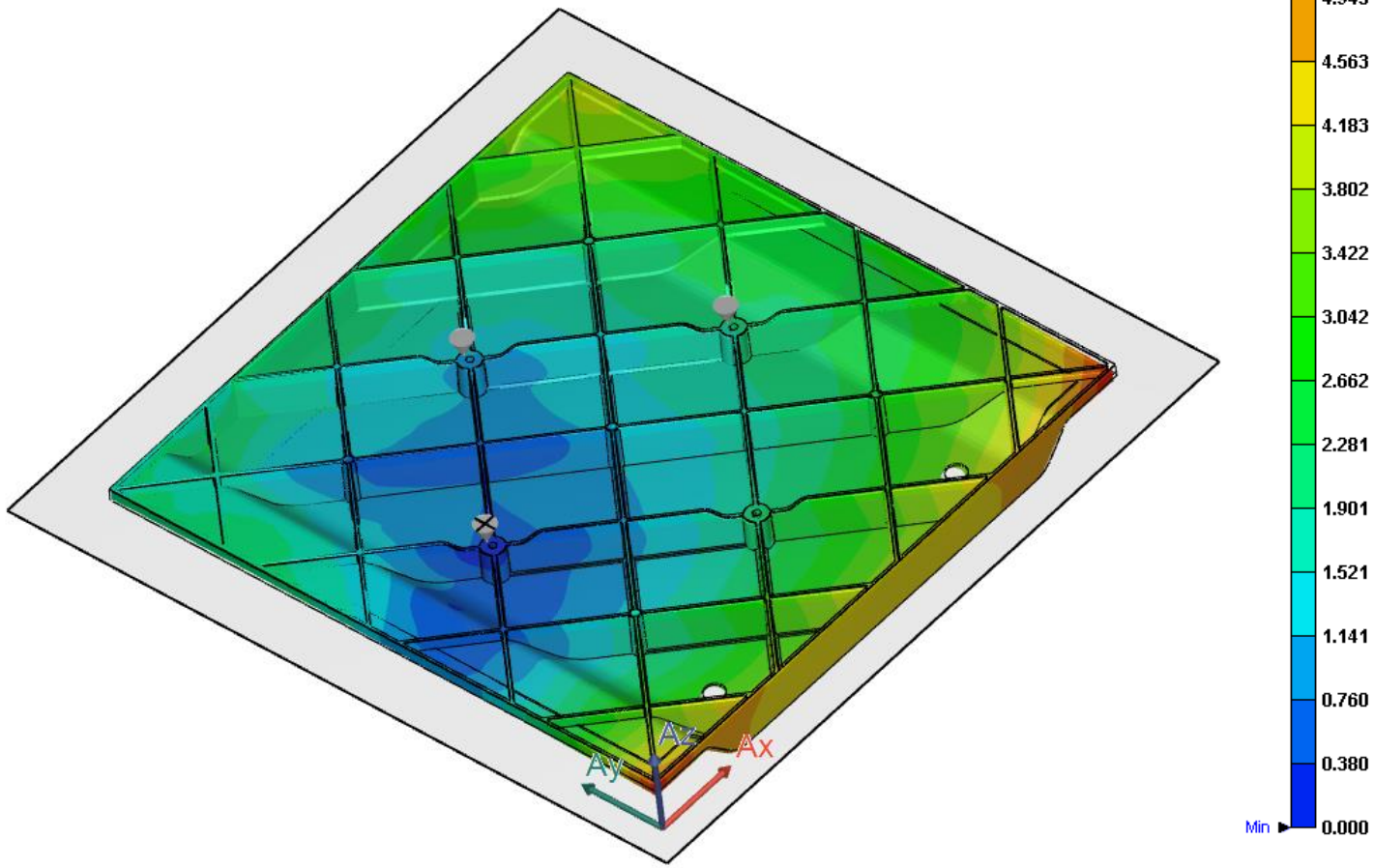
Process Simulation

- Model created in Moldex3D
- Organosheet laminate properties approximated based on a 50% filled glass fibre reinforced injection moulding compound
- Material data card within Moldex3D was modified to include the organosheets mechanical properties and CTE

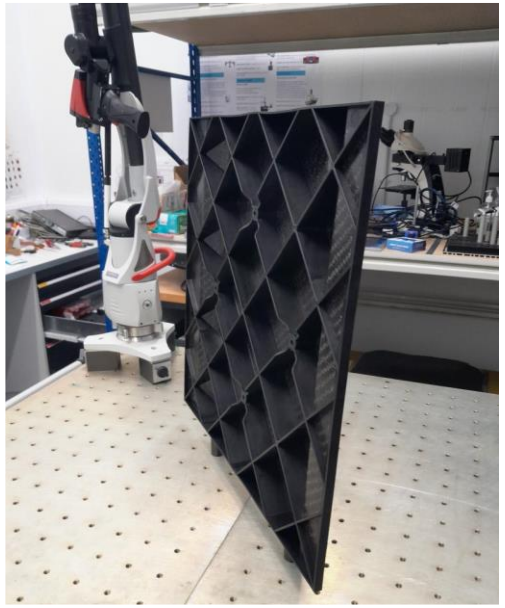


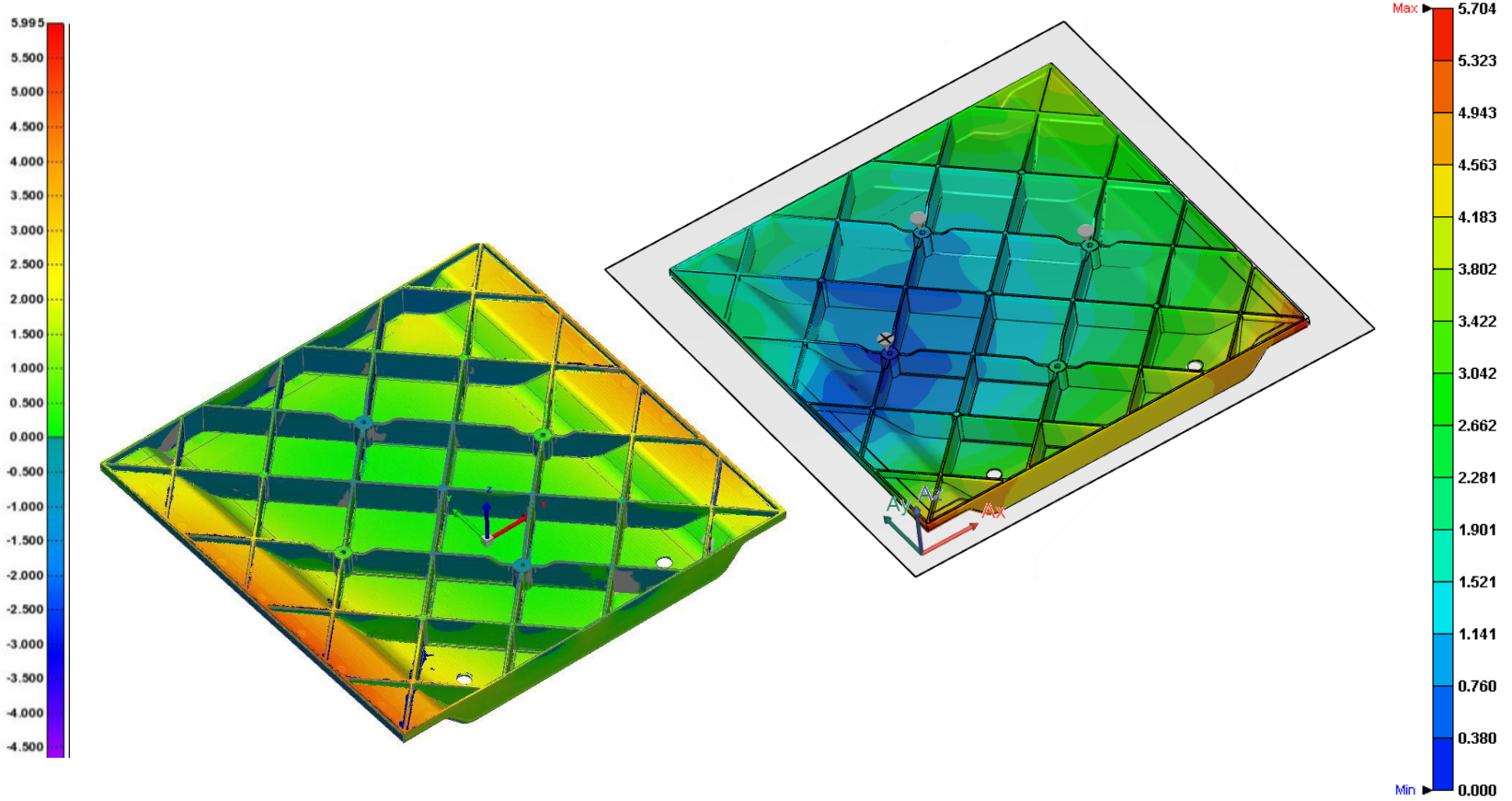
Warpage Simulation

- Warpage simulation was carried out in Moldex3D
- Anchor plane was created to allow for a comparison with metrology results
- Maximum deflection 5.704 mm
- Average deflection 2.132 mm
- Standard deviation 1.082



Validation



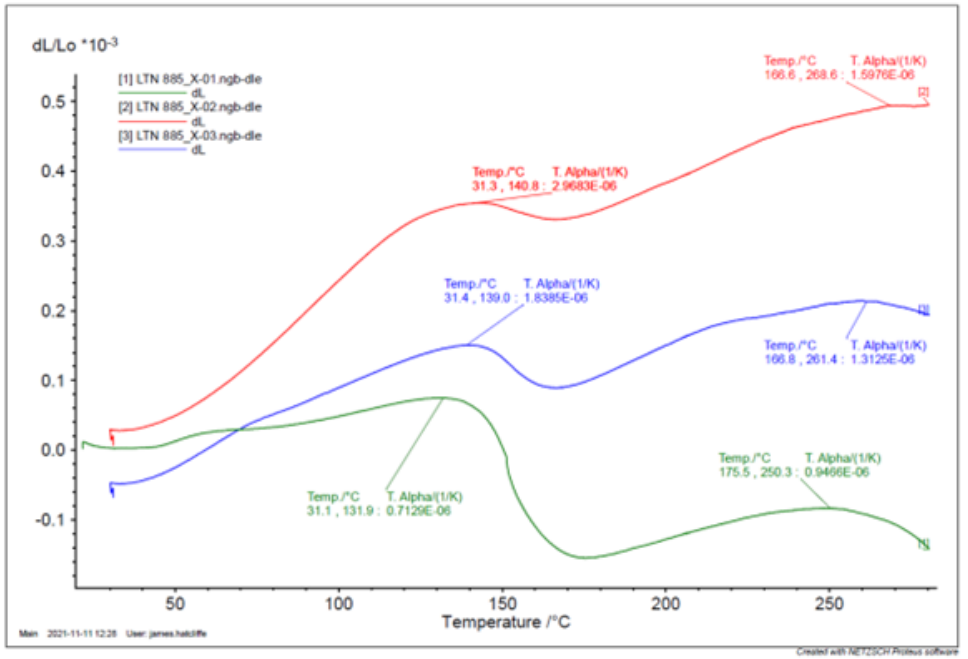


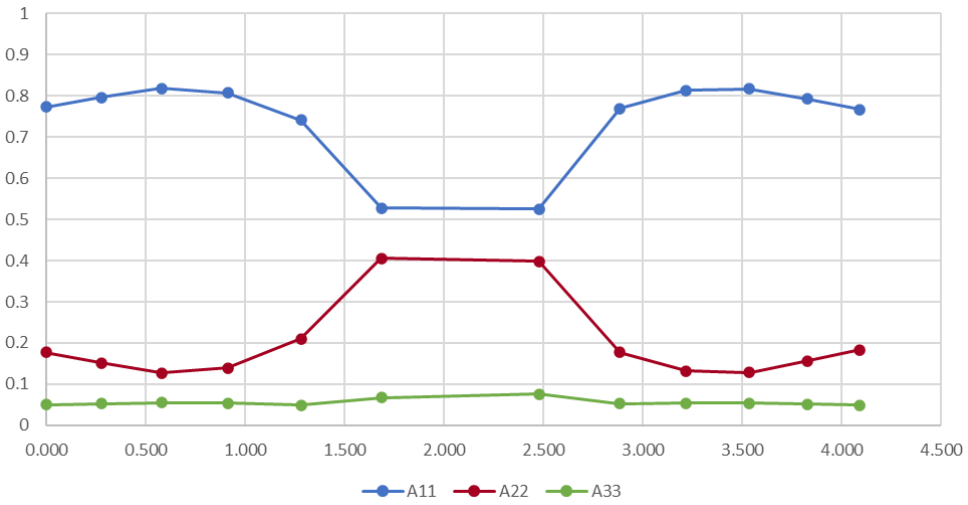
- 5 manufactured panels were scanned using a laser arm and compared to the CAD geometry
- Areas of warpage predicted by simulations doesn't correlate with metrology result
- Simulation accurately predicted the maximum deflection

	Simulation	Metrology	Percentage difference (%)
Average maximum deflection (mm)	5.704	5.902	3.35
Average deflection (mm)	2.132	1.776	20.05
Average standard deviation	1.082	1.702	36.43

Discussion

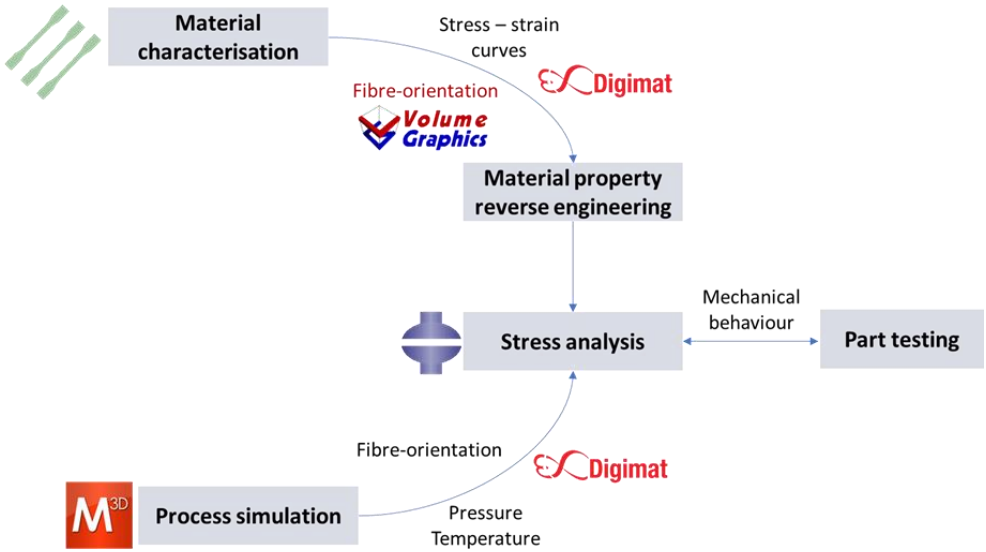
- Organosheet
  - CTE testing displayed significant deviations between samples
  - CTE measurements did not consider the effect of crystallisation during cooling
  - Mechanical properties were taken from the suppliers data sheet
- Fibre orientation distribution prediction
  - The short fibre orientation variation throughout the injection moulded part effects the overall warpage
  - Computational parameters used in simulation produced flatter fibre orientation curves than expected when looking across the cross section of a ribbed section





Future Work

- Fibre orientation distribution
  - generate more representative fibre orientation distributions using Moldex3D by altering computational parameters
  - This will be compared with micro-CT data generated by the University of Nottingham
- Create a FE model to predict mechanical behaviour of overmoulded part
- The FE model will aim to include
  - TPRCs healing interface model for thermoplastic composites
  - Organosheet compaction model developed by the University of Bristol and University of Nottingham
  - Using Digimat to generate material properties of the fibre filled injection moulding compound



Acknowledgments

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