Effect of Manufacturing Parameters on Thermo-mechanical Deformation of Composite Structures Using the powerRibs Technology
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Introduction
The patented ampliTex powerRibs technology allows to reduce weight of structural elements while maintaining flexural rigidity. A net of flax fibers threads is glued onto a substrate via vacuum-assisted resin transfer moulding, thereby increasing bending stiffness by means of neutral axis shifting. powerRibs have a low coefficient of thermal expansion (CTE) which can lead to thermo-mechanical deformations when combined with a substrate with different CTE. This project aims at finding new ways of characterizing thermo-mechanical deformations at the global and local scales, and finding solutions to prevent said deformations.

Global Deformation
• Effect due to powerRibs geometry and CTE mismatch with substrate
• Appears when sample is cured or post-cured at high temperature, then cooled down to room temperature
  > ΔT between “zero-strain temperature” and room temperature (23°C)
• This behaviour can be described with an homogeneous, orthotrophic equivalent bi-layer characterized by thickness, elastic moduli, coefficients of thermal expansion.
  > 2 layers needed to account for powerRibs bending without substrate

Thermo-mechanical Analysis
Dilatometry experiments to determine infused powerRibs and resin linear CTE, approximated by linear function.

Finite Elements Analysis of Local Curvature
• 3D solid elements
• Realistic model of powerRibs geometry (resin menisci, ribs crossing)
• Uniform temperature field, step from zero-strain temperature to RT
• Symmetry conditions in planes C and D, effectively simulating 4 powerRibs unit cells
• Adding high CTE material interlayer (polymer) between substrate and powerRibs compensates substrate shrinkage
• Predicts global curvature, reduction of print-through effect

Multi-layer Analytical Model[1]
• Estimates curvature of multi-layer strip (beam, 1D) with ΔT
• Layers thicknesses, elastic moduli and linear CTE as parameters
• Model fitted with experimental results to determine linear CTE of equivalent bi-layer in wavy ribs direction
  > Simplified model without substrate and 2 layers of identical thickness
  > Parameters fitted to match experimental curvatures
  > Linear CTE in flat ribs direction is equal to powerRibs CTE determined via TMA
• Validation on samples with aluminum substrate, curvature and zero-strain temperature was measured and compared to model > successful prediction

References