Contouring Residual Stress: A New Frontier for Polymer Composite Characterization

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Polymer composites offer exceptional strength-to-weight ratios compared to metals, but they face a crucial challenge in characterizing residual stress generated during curing process, caused by micro and meso-scale contractions between fibres and matrix and lamina respectively. These stresses affects structural integrity, exemplified by the NASA X-33's failure due to unchecked residual stress. Analytical models are expensive, relying on cure and temperature dependent physio-chemo-rheological properties, while characterizing bulk residual stress in polymer composites remains a challenge with no current experimental approach available [1].

The Contour Method, a relatively new technique [2] for characterizing residual stress, involves sectioning the component into two halves, measuring the out-of-plane deformation of the cut surfaces, and applying the measured deformation map to a finite element model for back-calculating the original residual stresses. The first research challenge in applying the Contour Method to non-metallic materials, such as epoxy-Carbon Fibre Reinforced Polymer composites, is developing a suitable method for cutting the material. The study presents results of cutting trials on symmetric cross-ply laminate using diamond wire cutting, meticulously assessing the cut surfaces using optical and Scanning Electron Microscopes. Residual stresses in the polymer composite measured by the Contour Method are presented and compared with results of Classical Laminate Theory and numerically predicted thermal contraction residual stresses. The Contour results exhibit a strong alignment with analytical and simulated stress fields, marking its successful application for the first time on polymer composites.

References

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