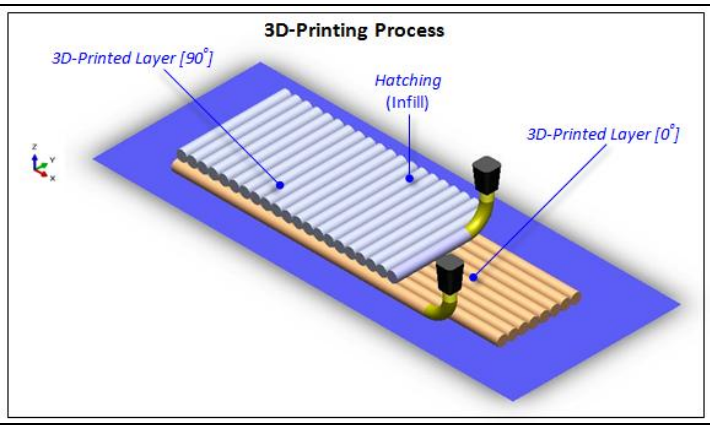
3D-Printed Chopped Composite

Challenge

A major challenge in a 3D-printing process employing short graphite fiber composites is to accurately analyze the constituent properties which would play a vital role in enhancing the efficiency of the manufacturing process and the performance of the final product.

The key objective of this case study is to (**1**) provide a comprehensive guide on how to model short-fiber composites containing manufacturing defects (particularly, in this exercise, void, interface reduction, and waviness); (**2**) predict the material mechanical properties; and (**3**) predict the most effective fiber orientation for any given manufacturing methodology.



3D-Printing Process

Solution

Given a 3D-printed UD lamina (thickness t = 0.0055 in) properties, obtained from two ASTM static tests, do the following:

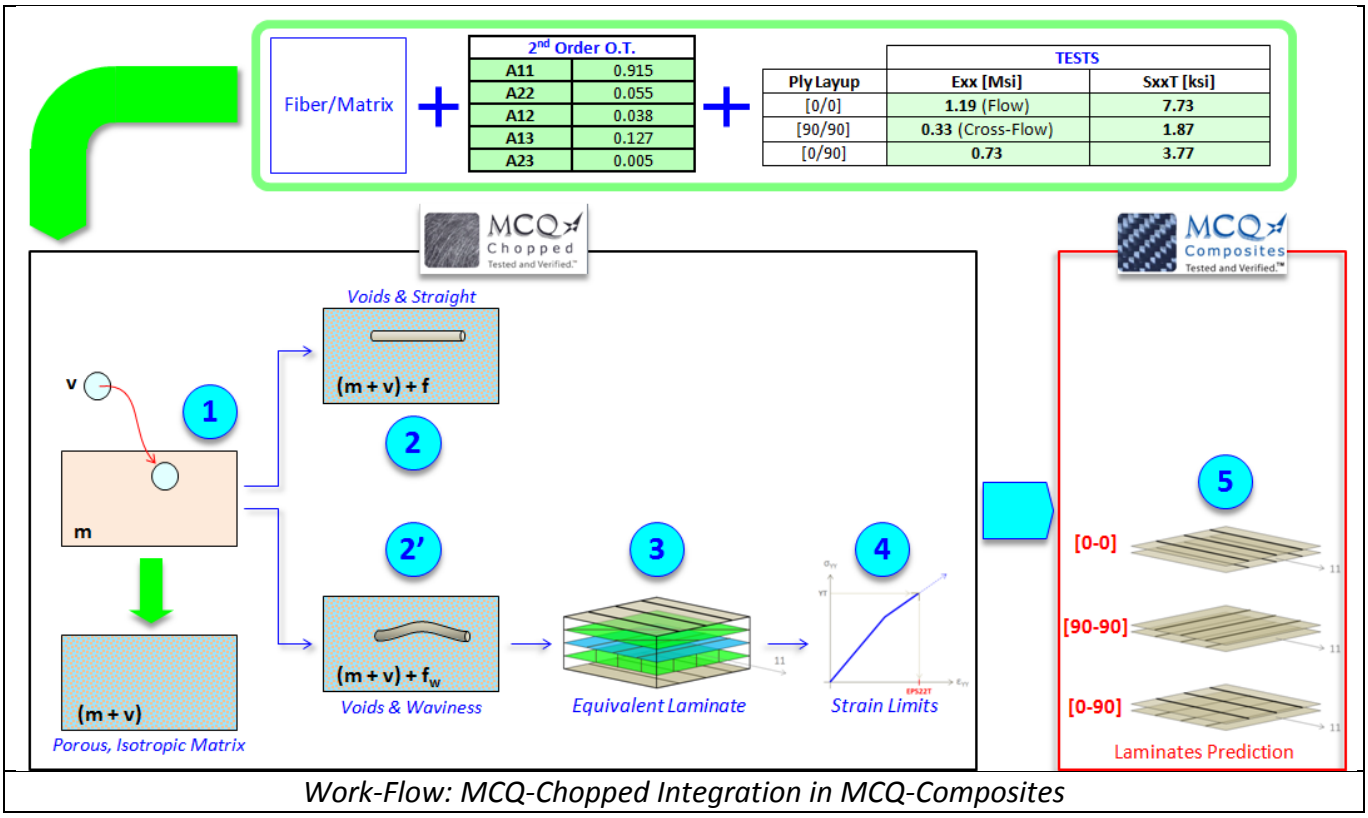
Reverse engineer the fiber and matrix effective (in-situ) properties of the UD lamina.

Fully analyze a 3D-printed, symmetric [0/90]s laminate.

Methodology involved in the case study includes Mori-Tanaka, Equivalent Laminate Analogy, Classical Laminate Theory (Analytical)

The step by step process involved in this case study as well as a work-flow chart which provides the virtual description is shown next:

- **Step-1:** Porous Isotropic ABS-matrix Determination
- **Step-2:** Porous Straight AS4-ABS Composite Parameters Calibration
- **Step-2':** Porous Wavy AS4-ABS Composite Parameters Calibration
- **Step-3:** Equivalent Laminate Stiffness Determination
- **Step-4:** Equivalent Laminate Strength Determination
- **Step-5:** 3D-Printed Layers Performance Prediction



Work-Flow: MCQ-Chopped Integration in MCQ-Composites

Results & Conclusion

- Fiber and matrix effective (in-situ) material properties for a chopped fiber coupon while considering the effect of defects.
- Prediction of the elastic and strength performance of a 3D-printed chopped composite build, having the 4 printed layers oriented as [0/90]s (each layer being manufactured with a 3D-printing process).
- The laminate Progressive Failure Analysis (PFA) results ply damages, etc.; can easily be extracted from this study as well.
- The calibration process generates fiber and matrix in-situ properties, while the prediction process produces the elastic and mechanical properties of the given 3D-printed laminate.

Key Highlights & Benefits
Product: MCQ-Chopped and MCQ-Composites
Industry: Aerospace and Automotive
Application: 3D Printing
Benefits: (1) De-Homogenization Approach: models composite constituents and chopped fiber orientation; (2) Considers effect of Defects; (3) Accurately predicts strength in addition to stiffness

Related Publication

Numerical Simulation of Big Area Additive Manufacturing (3D Printing) of a Full Size Car. SAMPE Journal 2015.