3D printing of continuous fiber composites, challenges and future opportunities

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Additive manufacturing (AM) methods for continuous fiber composites

- Automated fiber placement (Tape laying)
- Fused deposition modeling (FDM)
Additive manufacturing (AM) methods for continuous fiber composites

- Fused deposition modeling (FDM)
  - Pre-impregnation of the fiber
  - In-situ fiber impregnation

Materials
- Commonly used thermoplastic polymer matrices: ABS, PLA, PETG, Nylon, etc.
- Fiber: Fiberglass, Carbon, Kevlar, etc.
Additive manufacturing (AM) methods for continuous fiber composites

- Fused deposition modeling (FDM)
  - In-situ fiber impregnation
Evaluating mechanical performance and manufacturing quality of the 3D FDM printed composites

- Mark two FDM 3D printer for continuous fiber composites
  - Two nozzles: one for fiber bundle embedded in resin, and one for Nylon
  - Pre-impregnated fiber technique
  - Thermoplastic matrix: Nylon
  - Fiber: Fiberglass
Mechanical tensile tests

Geometry design
3D printed specimens for Mechanical tensile tests
Micrograph of the 3D printed specimens

Cross section view
Six 3D-printed pieces fabricated from chopped short carbon fiber and ABS resin were assembled to make a 13 m long mold. The surface of the mold was laid up with fiberglass (Oak Ridge National Laboratory).

Integration of AFP and 3D printing

- 3D printing to fill the gaps that AFP cannot cover

Rakhshbahar M. and Sinapius M., Combination of Automated Fiber Placement (AFP) and Additive Layer Manufacturing (ALM), J. of composite sciences, 2018
Manufacturing curved fiber composites

- Curved fiber composites
  - 60% reduction in stress concentration factor
  - 40% increase in the x-axis stiffness of the plate

Zhang, H, et al., Performance-driven 3D printing of continuous curved carbon fibre reinforced polymer composites: a preliminary numerical study, Composite B, 2018
Conclusion

- Higher **accuracy** in material placement, **design flexibility**, in situ production, no mold requirement, less waste and higher **sustainability** are advantages of 3D printing.

- Challenges associated to 3D printing include improving **mechanical performance**, developing **cost effective materials** and more efficient printing technology.

- Manufacturing of **molds** for wind turbine blades, manufacturing of optimized **curved fiber** composites, **Integrated 3D printing and AFP**, etc. are some of the promising future applications of 3D printing/AM.