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

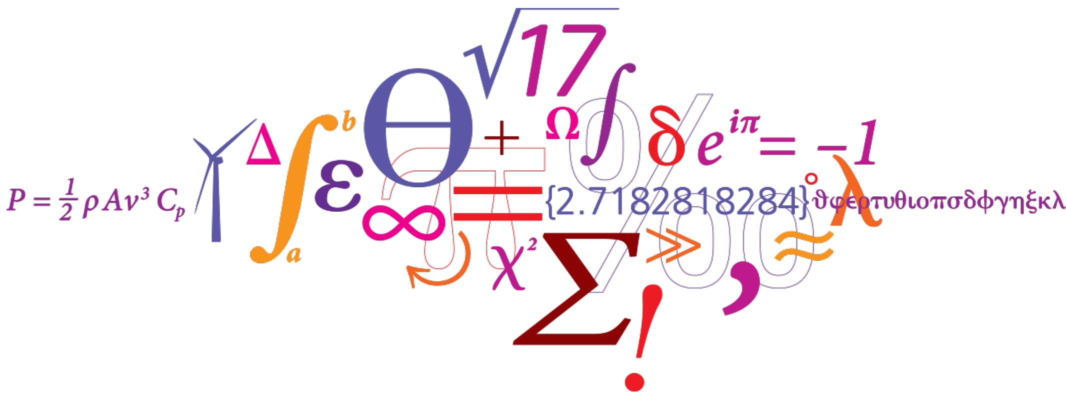
Ali Sarhadi, Reseacher

Martin Alexander Eder

Søren Fæster

Tom Løgstrup Andersen

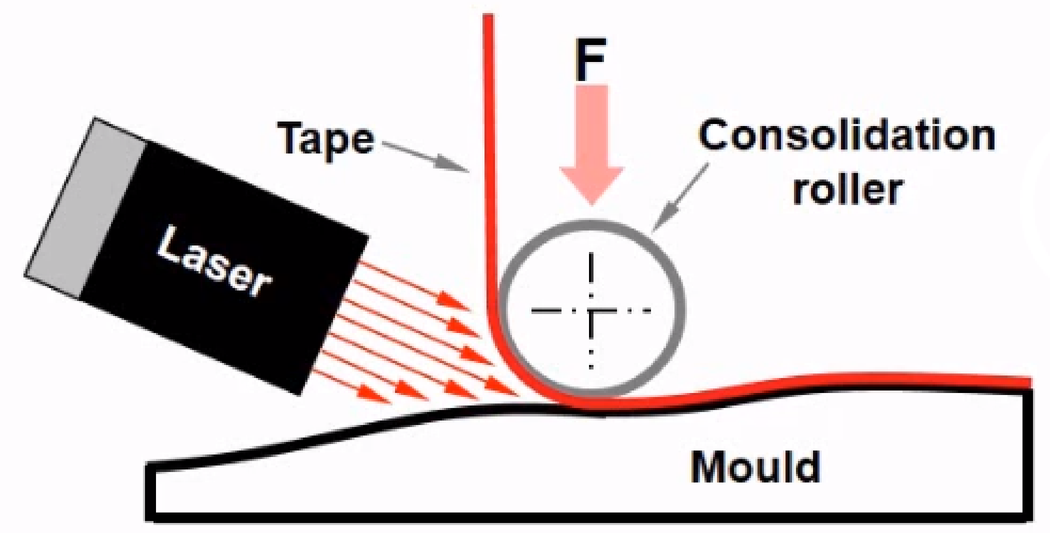
Bo Madsen



DTU Wind Energy
Department of Wind Energy

Additive manufacturing (AM) methods for continuous fiber composites

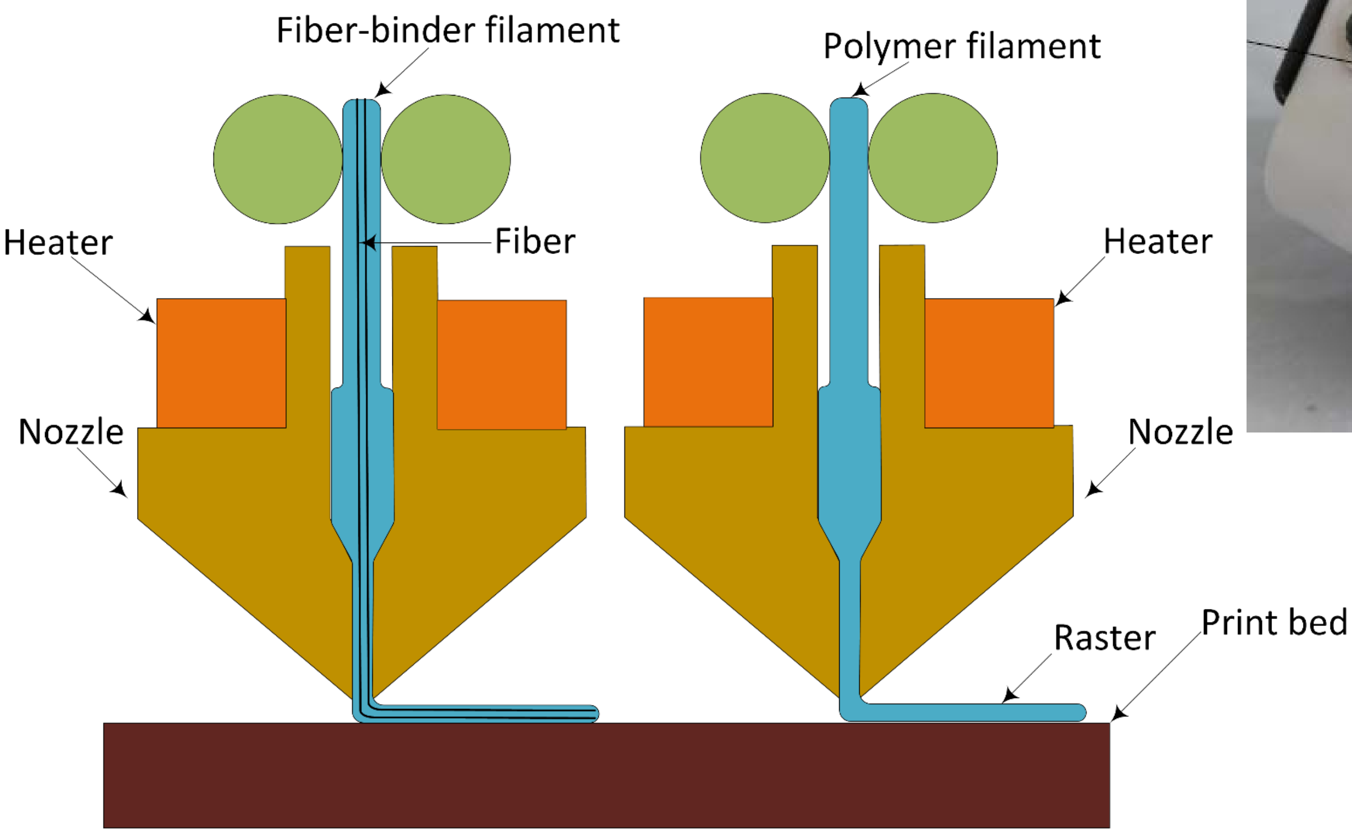
- Automated fiber placement (Tape laying)
- Fused deposition modeling (FDM)



Automated fiber placement (AFP)

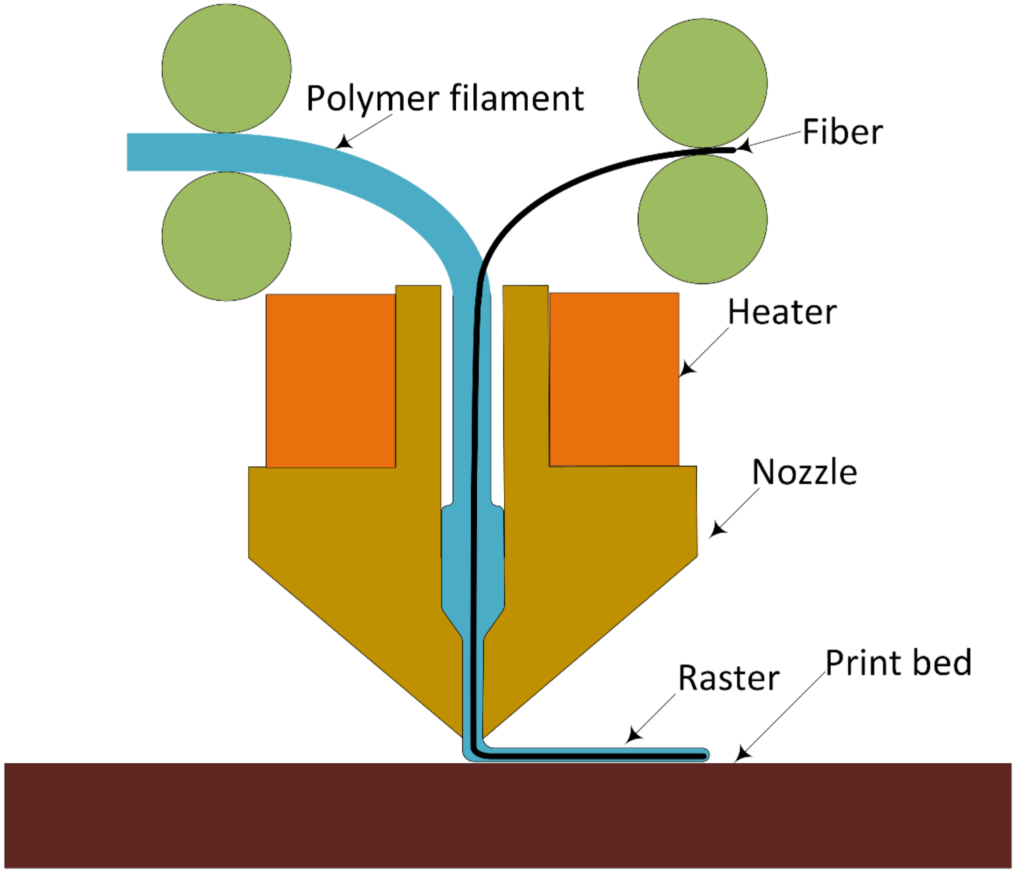
Additive manufacturing (AM) methods for continuous fiber composites

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



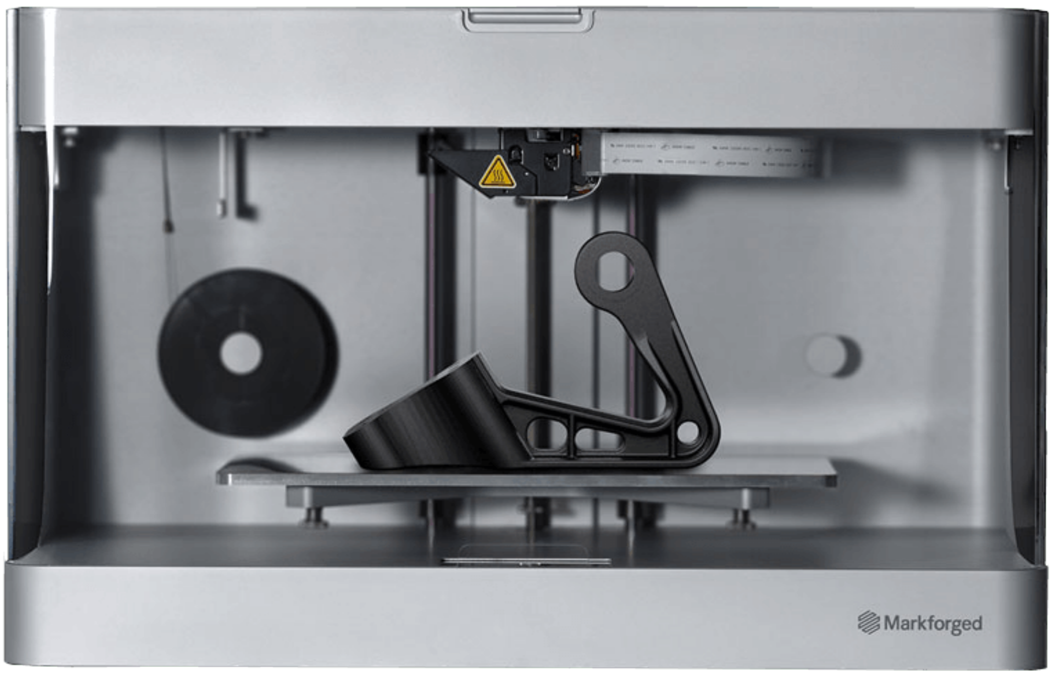
Additive manufacturing (AM) methods for continuous fiber composites

- Fused deposition modeling (FDM)
- In-situ fiber impregnation



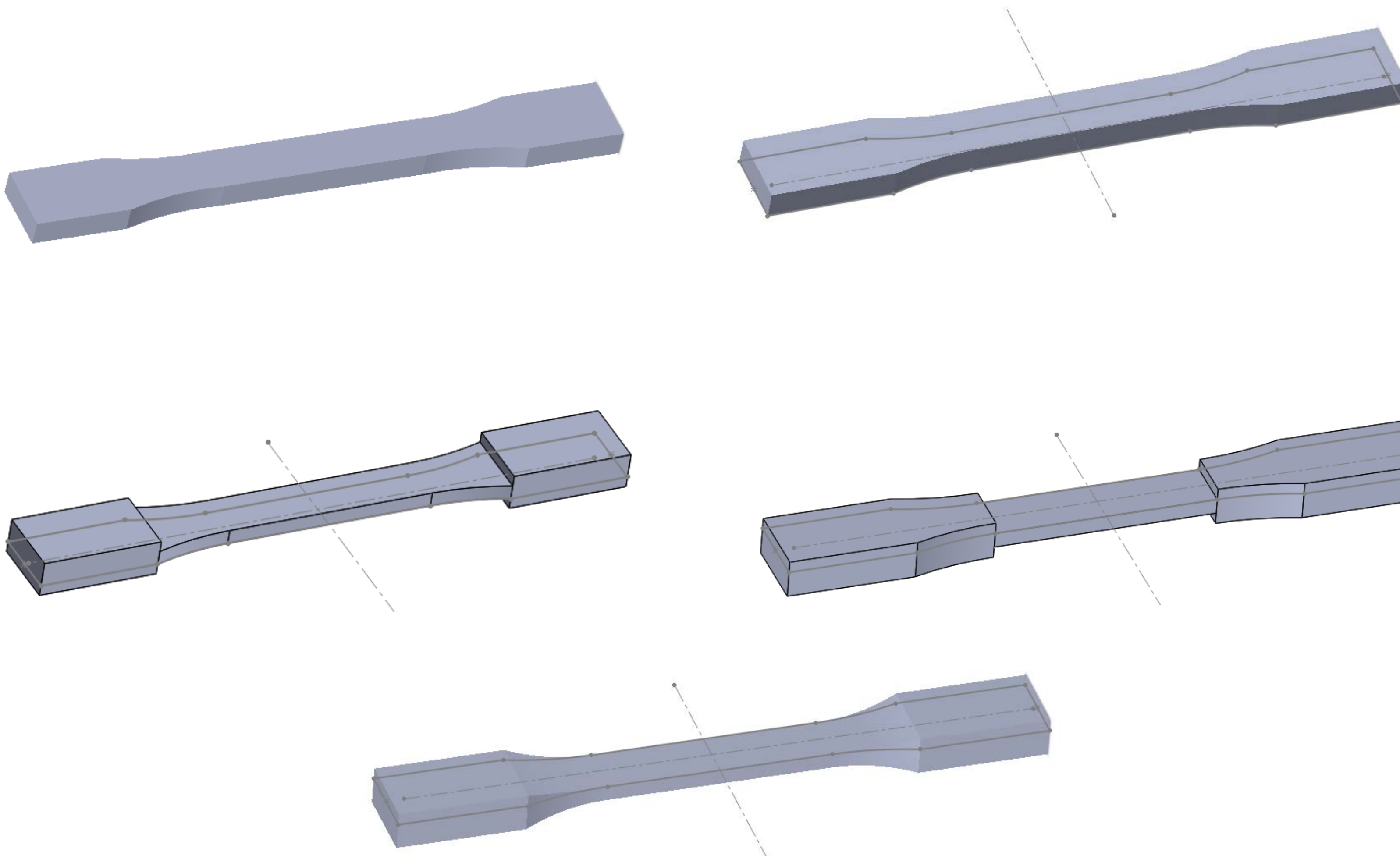
Evaluating mechanical performance and manufacturing quality of the 3D FDM printed composites

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

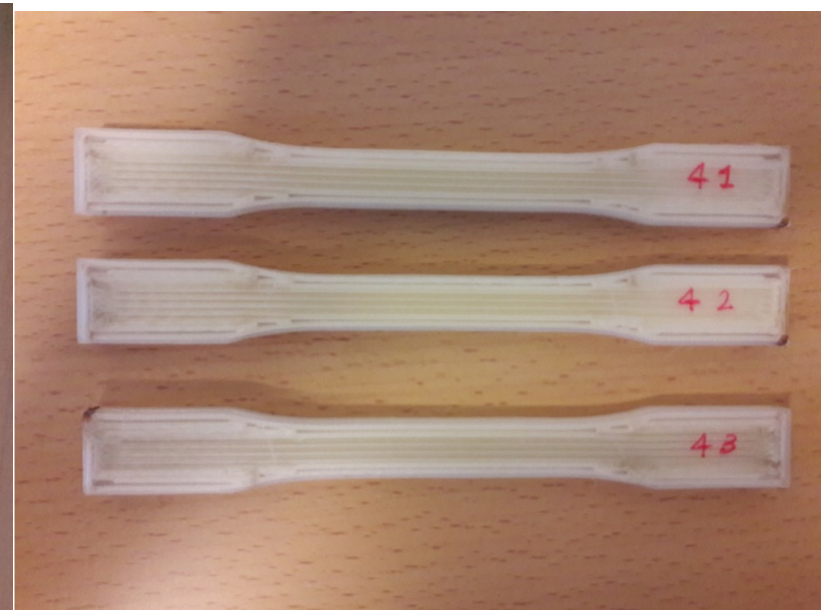


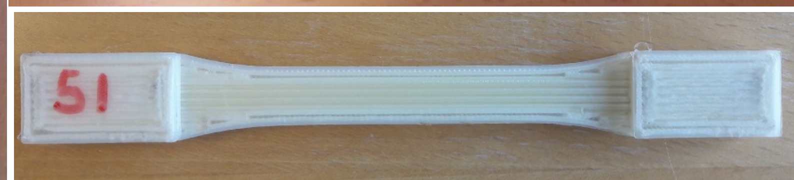
Mechanical tensile tests

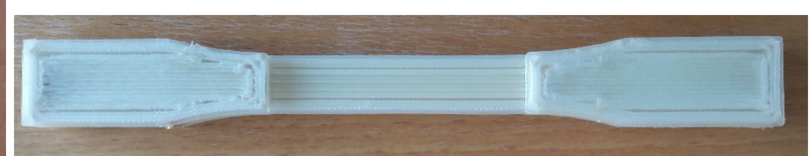
Geometry design

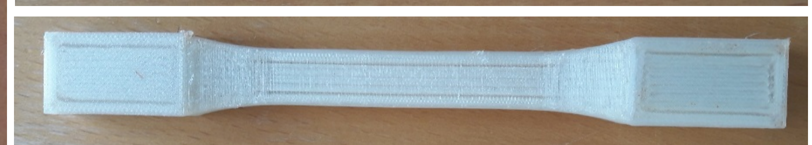


3D printed specimens for Mechanical tensile tests



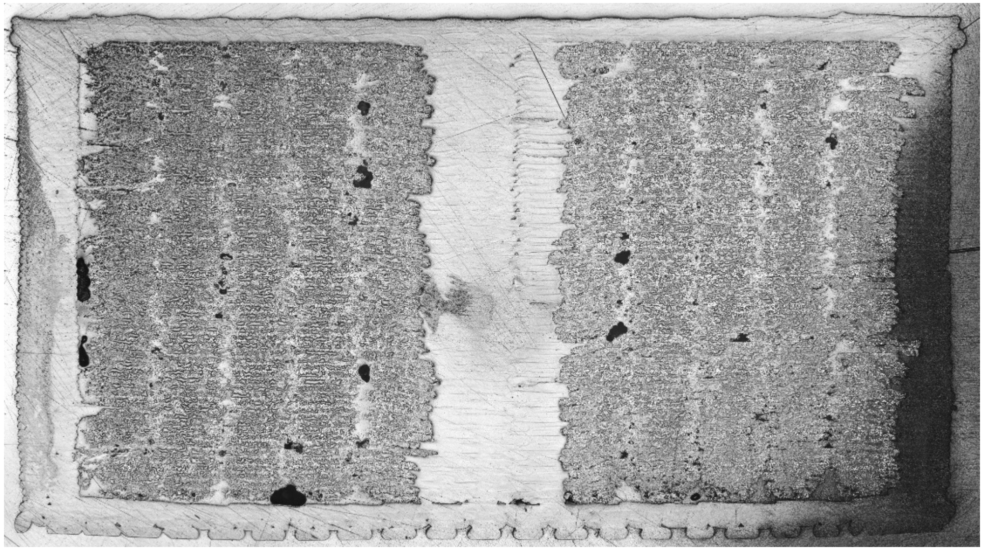


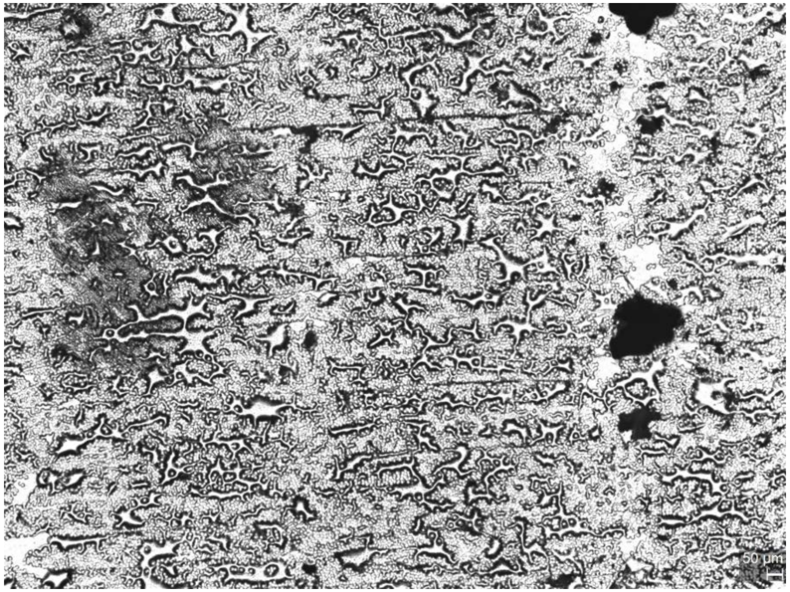




Micrograph of the 3D printed specimens

Cross section view





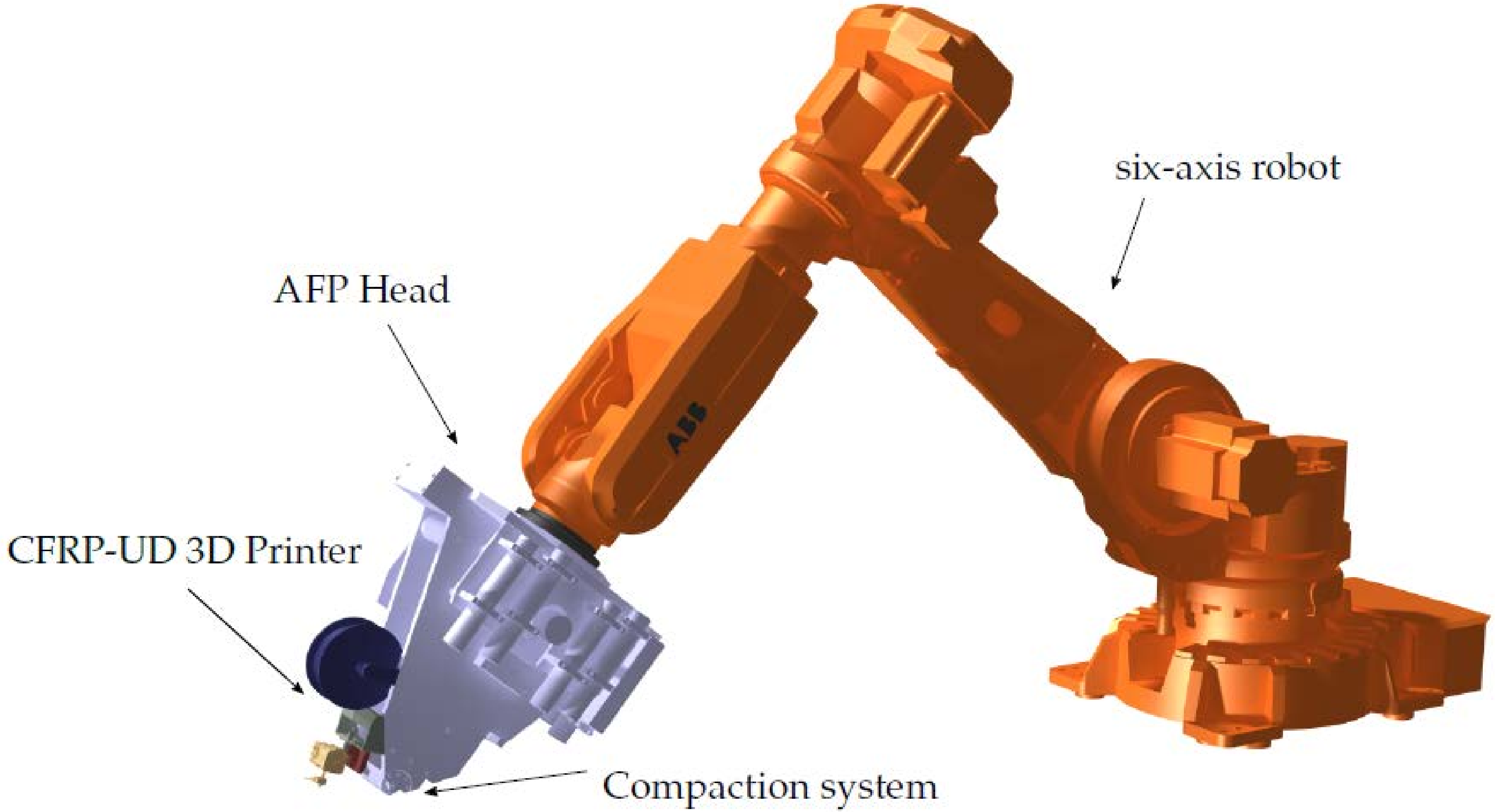
Big Area Additive Manufacturing (BAAM)

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)

B. K. Post, B. Richardson, R. Lind, L. J. Love, P. Lloyd, V. Kunc, B. J. Rhyne, A. Roschli, J. Hannan, S. Nolet, K. Veloso, P. Kurup, T. Reno, and D. Jenne, “Big area additive manufacturing application in wind turbine molds”, in Proceedings of the 28th Annual International Solid Freeform Fabrication (SFF) Symposium - An Additive ManufacturingConference, Austin, TX, 2017

Integration of AFP and 3D printing

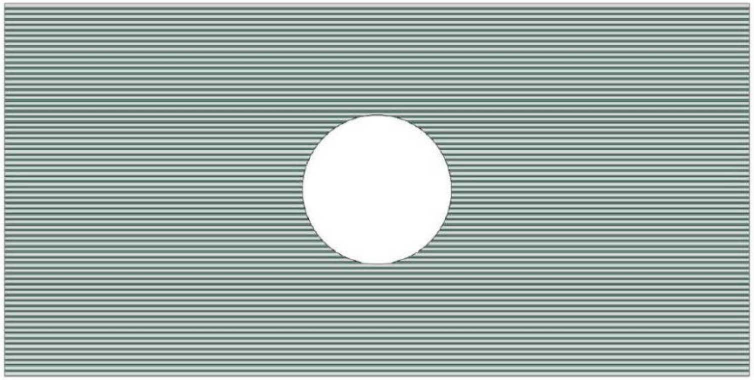
- 3D printing to fill the gaps that AFP cannot cover



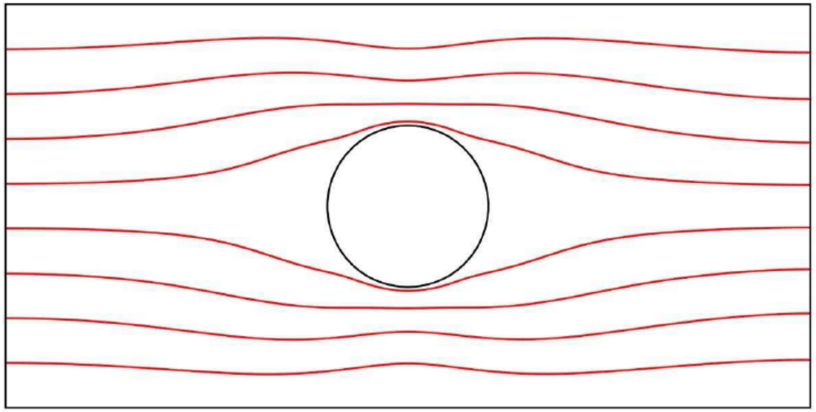
Rakhshbahar M. and Sinapius M., Combination of Automated Fiber Placement (AFP) and Additive Layer Manufacturing (ALM), J. of composite sciences, 2018

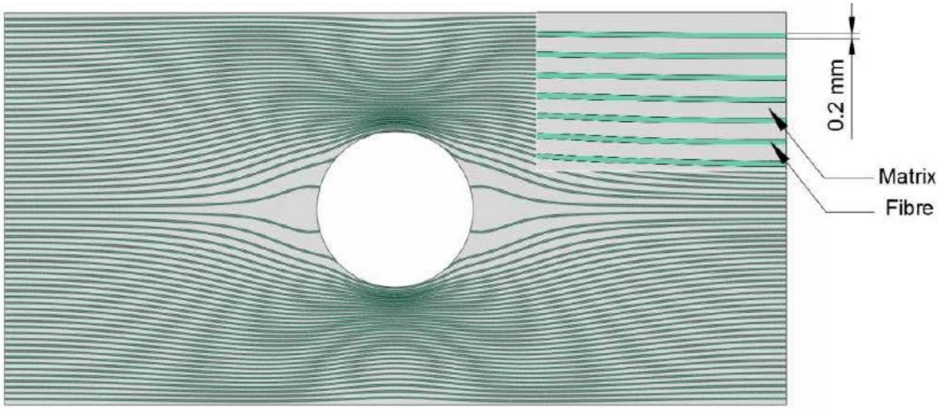
Manufacturing curved fiber composites

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



Maximum principal stress trajectories





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.

THANK YOU!