Recyclability of Large-Scale 3D Printed Formwork

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Materials

Five sets of WF-aPLA and five sets of CF-ABS formwork were manufactured using large-scale extrusion based 3D printing, on the Ingersoll Masterprint at the University of Maine's Advanced Structures and Composites Center (ASCC). Both materials have 20% reinforcement by weight.

Figure 1: 3D Printed Formwork Sets

Methods

Thermal mechanical testing was conducted to establish a baseline for material properties. This baseline will be used to evaluate both the CF-ABS and WF-aPLA's viability for recycling.

Thermal tests such as thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) were conducted to determine the glass transition temperature and material impurity.

Mechanical tests were conducted to determine the tensile strength and tensile modulus of the materials. A modified ASTM D3039 was used to conduct the tensile tests.

Fiber lengths were determined by fiber isolation, through matrix dissolution. Microscopy with a Scanning Electron Microscope (SEM) and ImageJ was used to determine the baseline length of the fibers.

In Collaboration with: Oak Ridge National Laboratory

Baseline Properties

Table 1 is a summary of the thermal-baseline characterization of the CF-ABS & WF-aPLA.

Table 1: Summary of Baseline Thermal Properties

Property	CF-ABS	WF-aPLA
Glass Transition Temperature, Tg (℃)	101.8	54.40
Material Impurities/Effectiveness of Washing (% by weight)	0.0809	0.432
Fiber Length (um)	81.65	96.50

Table 2 is a summary of the mechanical-baseline characterization of the material.

Table 2: Summary of Baseline Mechanical Properties

Property	CF-ABS	WF-aPLA
Tensile Modulus - 11 Direction (MPa)	4623	4808
Tensile Strength - 11 Direction (MPa)	47.63	45.5
Tensile Modulus - 33 Direction (MPa)	4368	4348
Tensile Strength - 33 Direction (MPa)	45.63	45.3

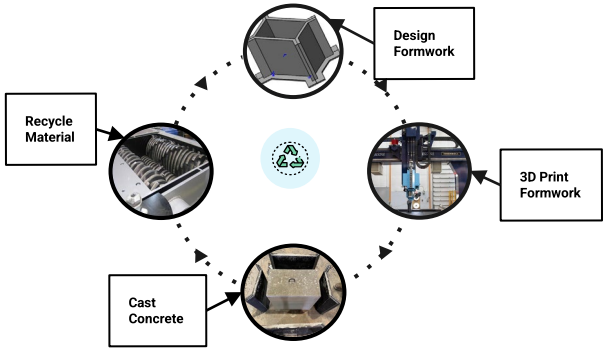

Figure 2: Recycling Cycle of 3D Printed Formwork

Subsequent Recycling Cycles

The baseline results will be used comparatively with all recycling cycles. They will act as a benchmark for the material, showing any degradation or alterations in material properties with subsequent recycling.

A total of six prints will be completed; meaning that five cycles of recycling will take place. A recycling cycle includes the grinding and pelletization of the material.

Upcoming Work

The establishment of the baseline has brought the project into its next phase. This next phase will include the mechanical recycling of the baseline material. The formwork sets will be shipped to ORNL. Once at ORNL the forms will be shredded and pelletized.

Following the pelletization, the material will be used to print new sets of forms.

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