Studying the Performance and Compatibility at the Boundary Interfaces of Multi-Material Composites Fabricated by Additive Manufacturing

IUPUC OFFICE OF STUDENT RESEARCH

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Introduction

Additive manufacturing has many applications within prototyping and creating structures that would be impossible to fabricate by normal means of production. A single material is typically used for its ease of use and strong structure. But when one material is combined with one or more materials additional properties can be given to a structure. This mixed material could have properties that improve the temperature it can sustain, improve the strength of the overall material, similar properties to another material but with other properties that are more desirable, and a vast many other possible properties that could be achieved.

This research project involved finding a process to mix 2 or more materials using additive manufacturing and studying the properties of the combined materials. Through tensile tests, tests of conductivity, and cross-sectional examination the material properties can be observed and can determine how well the mixed materials have combined.

Methodology

Additive manufacturing is a process that involves feeding a spool of material into a heating element at a controlled rate to prepare it to be extruded through the print head. Parts are printed through numerous layers of lines that build upon the previous layer until the part is fully fabricated.

For this research, the additive manufacturing process was used with 2 or more materials being fed into the heating element. The materials are collected into a mixer that allows for the materials to be combined before they are extruded. This allows the materials to have a controlled percentage of each material that is being used to fabricate a part. The temperatures used were based on the highest melting point of the materials.

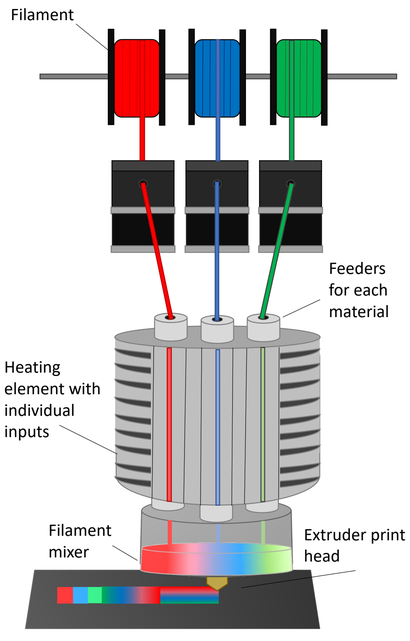
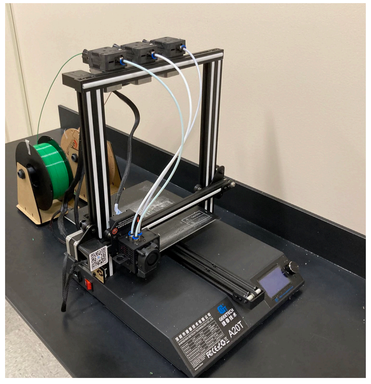


Figure 1: Schematic of Geeetech A20T Printer



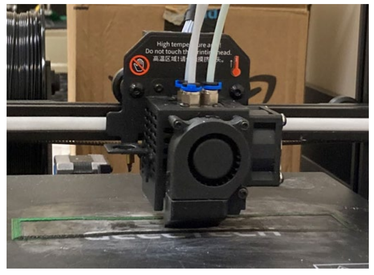


Figure 2: Geeetech A20T Printer

Results

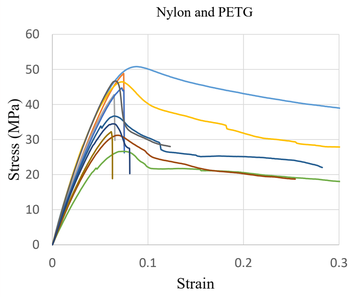
For this research, samples were created using 2 different materials that were mixed at a range of percentages of each. A sample of each material alone was included within this range. The Geeetech A20T printer was used to create the samples using its multi-material input capability. Nylon was used with all mixed samples and required 245°C for the print head, and 100°C for the print bed. All other materials used required a temperature within or below these temperatures. The samples created are ASTM D638 tensile tests type I and V. Each material was printed in increments of 10%, starting with a solid unmixed sample of the first material, and moving toward a solid unmixed sample of the second material.

Figure 3: Mixed tensile test sample

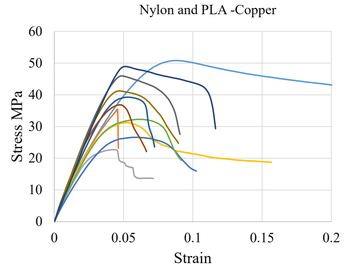
Material 1 (Nylon) / Material 2 (PETG)

Figure 4: Percentage fill of each sample

The first set of samples were a mixture of Nylon and PETG. These samples were tested for stress, strain, and modulus of elasticity. These tests were conducted to find how the mix percentage affected the structure of each sample:



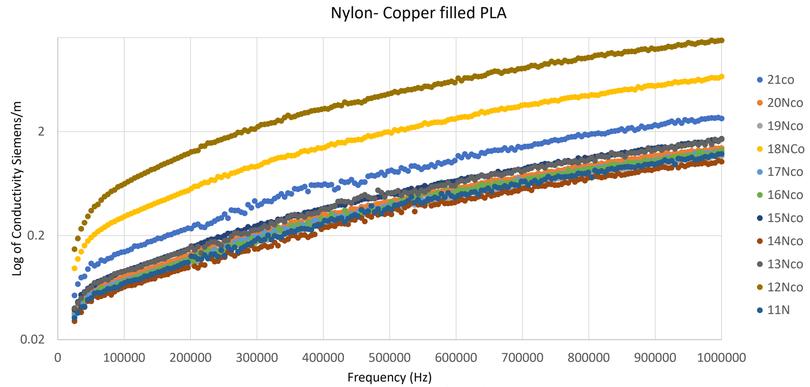
Samples	Materials	Nylon %	PETG %
1NP	Nylon, PETG	10	90
2NP	Nylon, PETG	20	80
3NP	Nylon, PETG	30	70
4NP	Nylon, PETG	40	60
5NP	Nylon, PETG	50	50
6NP	Nylon, PETG	60	40
7NP	Nylon, PETG	70	30
8NP	Nylon, PETG	80	20
9NP	Nylon, PETG	90	10
10P	PETG	0	100
11N	Nylon	100	0



Samples	Materials	Nylon %	Copper PLA %
12NCo5	Nylon, Copper PLA	90	10
13NCo5	Nylon, Copper PLA	80	20
14NCo5	Nylon, Copper PLA	70	30
15NCo5	Nylon, Copper PLA	60	40
16NCo5	Nylon, Copper PLA	50	50
17NCo5	Nylon, Copper PLA	40	60
18NCo5	Nylon, Copper PLA	30	70
19NCo5	Nylon, Copper PLA	20	80
20NCo5	Nylon, Copper PLA	10	90
21NCo5	Copper PLA	100	0

Figure 5: Tensile Test data and sample notation

Tests were conducted upon the samples that contained copper within the filament. They were tested for their conductivity and their resistivity. The purpose of these tests was to find out if the copper within the filament was conductive:



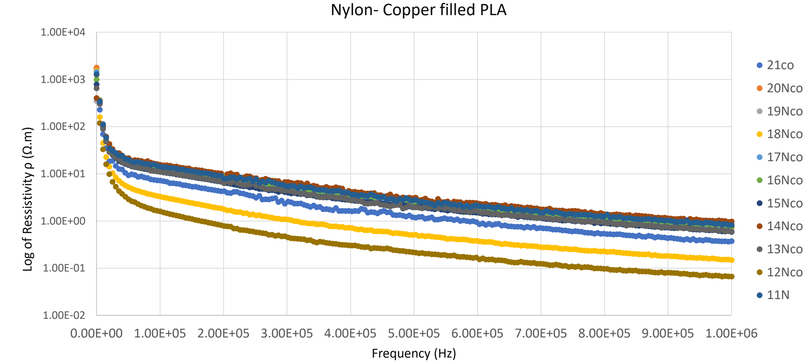


Figure 6: Conductivity and Resistivity of Copper filled PLA samples

Purpose

The purpose of this research was to set the procedure that can be used for research involving multi-material fabrication. The procedure will allow for a process to print multiple materials using the Geeetech A20T printer. A wide range of materials and how they interact with each other when printed together in various configurations of mixture.

References

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