FDM 3D Printing Mechanical Property Testing

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Abstract

In this experiment, the mechanical properties of 3-D printed specimens of different printing parameters were tested under tension. The printing parameters of these specimens were: print orientation, infill density, and surface resolution. Parts were printed in Onyx (a composite material made of nylon with carbon chopped microfibers) with a Fused Deposition Modeling (FDM) printer called the Markforged Onyx Pro. Factorial sets of specimens using all various parameters are printed and tested to create a reference table for future engineering projects. Specimens were then printed in Onyx with added directional continuous fibers (fiberglass) to understand the benefits of directional reinforcement on mechanical properties.

Background

3D printing allows the user to select many combinations of print settings. These include: infill %, layer thickness, orientation, infill pattern, wall thickness, wall count, nozzle temperature, bed temperature, material…
Mechanical properties can change drastically based on these settings. Understanding these relationships allows a designer to obtain specific desired properties in 3-D printed parts.

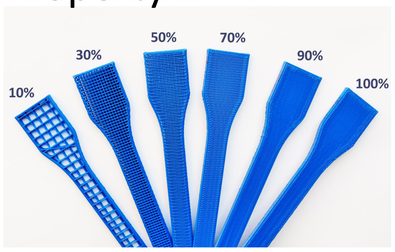
Experimental Procedures

Specimens were pulled to ASTM D638 standards

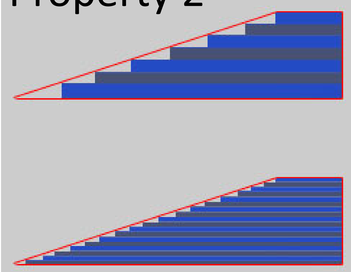
a) 12 different combinations of print settings using only Onyx material
   1. 100%, 50%, 10% fill
   2. 0.1mm/0.2mm layer height
   3. Upright/Flat print orientation

b) 4 specimen sets with various amount of directional fiberglass added during the build Onyx
   1. All flat, 100% fill, 0.1 mm layer height
   2. 2, 4, 8, and 16 layers of fiberglass added to the part aligned in direction of pull

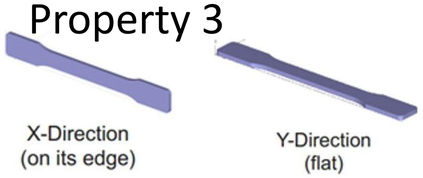
Property 1



Property 2



Property 3



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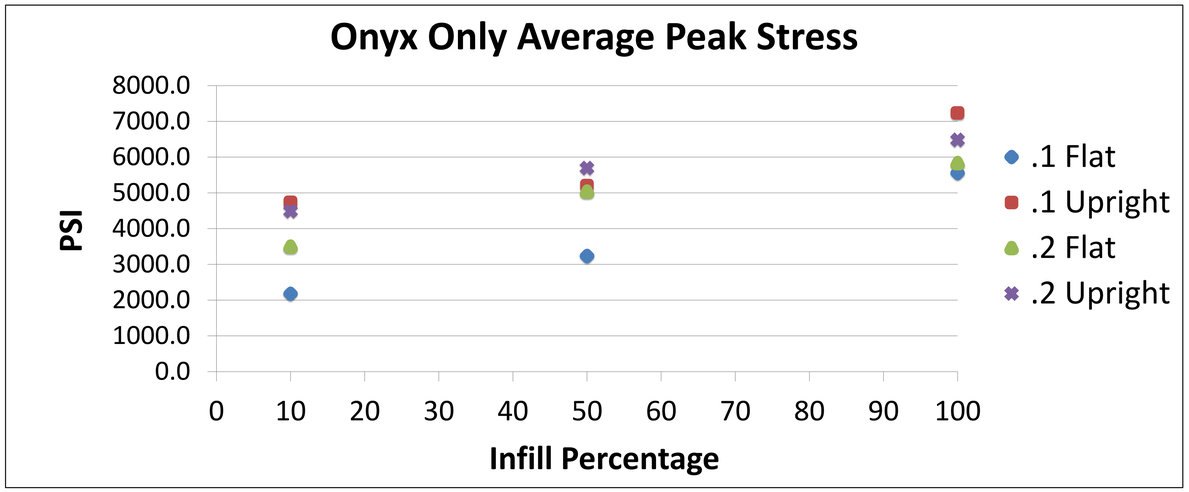
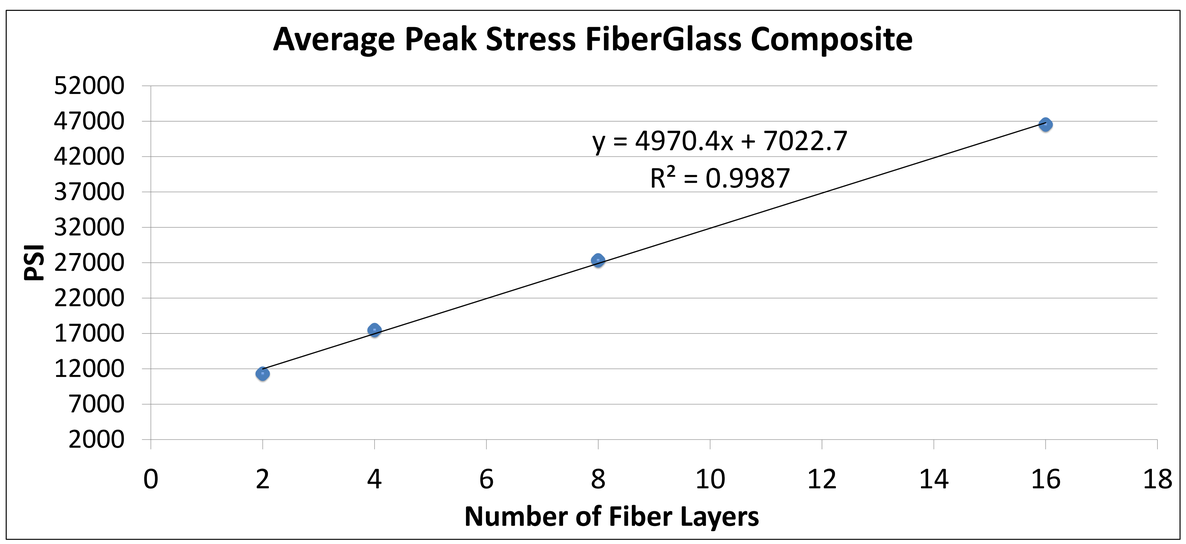


Conclusions - Onyx Only

1. Upright print orientation stronger than flat orientation.
   WHY: Long internal fibers line up in the direction of pull.
2. Strength increases with % infill. Rate varies with other process parameters.
   WHY: As density increases more fiber is present to carry load.
3. Larger layer height tends to increase the strength for flat print orientation and decrease strength for upright.
   WHY: This is a question that does not yet have an answer. Needs more study.



Conclusions - Fiberglass Composite

1. Fiberglass drastically increases the strength of the part
2. Peak stress increases linearly with number of layers.