FDM 3D Printing Mechanical Property Testing

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Abstract

In this experiment, the mechanical properties of 3D printed specimens of different printing parameters were tested under tension. The printing parameters of these specimens were: surface resolution, infill density, and print orientation. Parts were printed in Acrylonitrile Butadiene Styrene (ABS) plastic with a Fused Deposition Modeling (FDM) printer called the Stratasys UPrint SE Plus. Specimens were first printed similar to Stratasys published mechanical property standards and then tested to form a control on these known properties. Factorial sets of specimens using all various parameters were then printed and tested to create a reference table for future engineering projects.

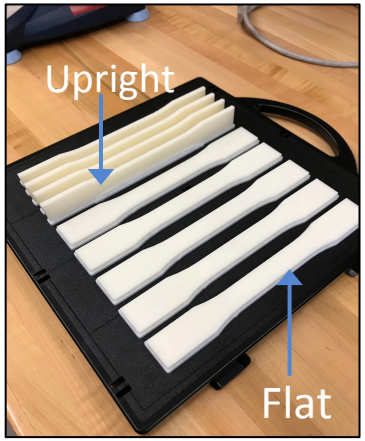
Background

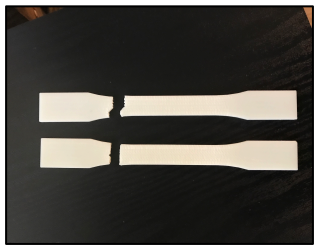
- 3D printing allows the user to select many combinations of print settings
- These include: infill %, layer thickness, infill pattern, orientation, wall thickness, wall count, nozzle temperature, bed temperature, material…
- Mechanical properties can change drastically based on these settings

Experimental Procedures

a) Specimens were pulled to ASTM D638 standards
   1. Results of first set of parts were compared to published data to verify test procedure.
   2. Total of 60 specimens were then printed and tested

b) 12 different combinations of print settings
   1. Upright/Flat print orientation
   2. Solid, High density, Low density printer fill settings
   3. 0.01mm/0.013mm layer resolution (height)





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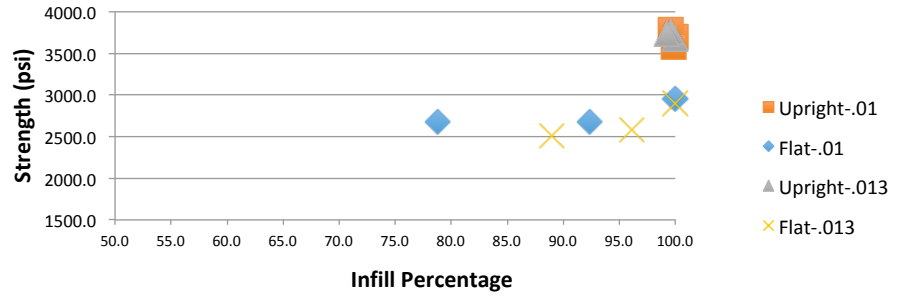
Analysis

a) Test procedure verified: test data matched published data ± 4%
b) Average yield stress
   1. Because of the nature of specimen geometry, upright version's infill percentage doesn't change despite changes in setting 2 or 3, making comparisons between upright and flat lower density specimens irrelevant



Configuration	.01 solid Flat	.01 solid Flat	.01 high fill flat	.013 low fill flat	.01 low fill flat	.013 high fill flat
Time to print	2:01 hr	1:30 hr	1:54 hr	1:29 hr	1:48 hr	1:30 hr
Mass	8.25 g	8.38 g	7.62 g	8.35 g	6.5 g	8.37 g
Configuration	.01 solid Upright	.01 solid Upright	.01 high fill Upright	.013 low fill Upright	.01 low fill Upright	.013 high fill Upright
Time to print	4:46 hr	3:14 hr	4:49 hr	3:14 hr	4:46 hr	3:14 hr
Mass	8.31 g	8.41 g	7.99 g	8.38 g	7.39 g	8.35 g

Conclusions

1. Upright stronger than flat orientation by 20 %
   - WHY: Long internal fibers line up in the direction of pull
2. Little drop off of strength from solid to high to low density
   - WHY: Weight and infill % don't change significantly due to geometry
3. Little drop off of strength in layer resolution
4. BIG trade off in TIME for Flat vs Upright