Benchmarking Efficiency and Print Quality of FFF and SLA 3D Printing Technologies

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Research Objective

The objective of this research is to establish a detailed power consumption, process duration, and surface roughness comparison between the two most common additive manufacturing (AM) technologies: Fused Filament Fabrication (FFF) and Stereolithography (SLA) This presentation will report the current findings of the ongoing research study detailing the benchmarking of both processes.

Background

As additive manufacturing (AM) is becoming ubiquitous, the two most prevalent 3D Printing technologies in almost every sector of life are Fused Filament Fabrication (FFF) and Stereolithography (SLA) resin printing. While FFF printing is a cheaper, faster process, SLA is considered to have better surface quality and dimensional accuracy.

Experimental Setup

The 3D printed specimens were printed in the Tennessee Tech University iMakerSpace using Raise3D Pro2 FFF printers and FormLabs Form2 SLA resin printers. For each print, the layer height, infill pattern, and infill density were varied to perform a 3x3x3 factorial experimental design.

- Infill Patterns:
  - •Honeycomb (hex), line, triangle
- Infill Densities:
  - •10%, 20%, 30%
- Layer Heights (mm):
  - •0.025, 0.05, 0.1

The print specimens were then measured using a Mitutoyo handheld surface roughness tester to determine the Ra surface roughness value in µin.

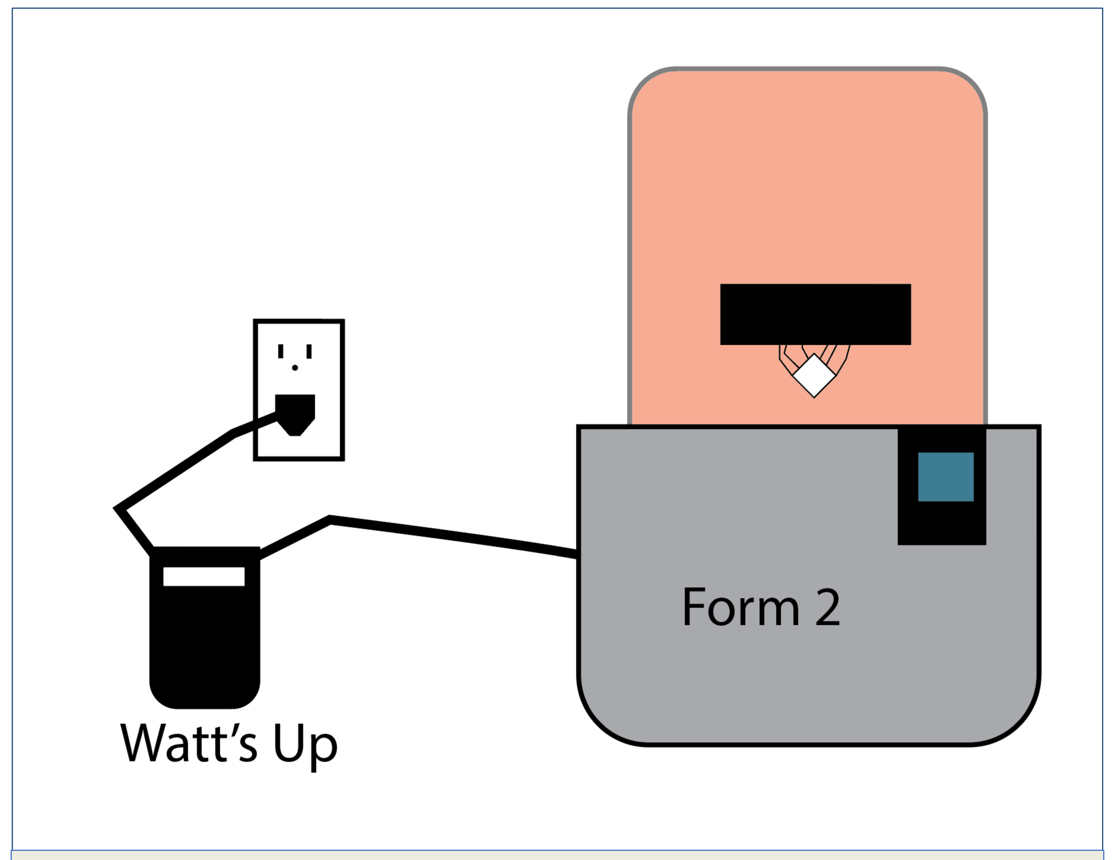
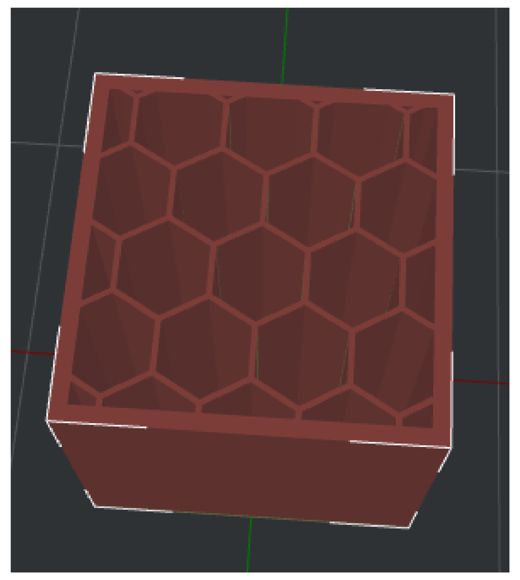


Diagram of FormLabs Form2 SLA printer and WattsUp power meter

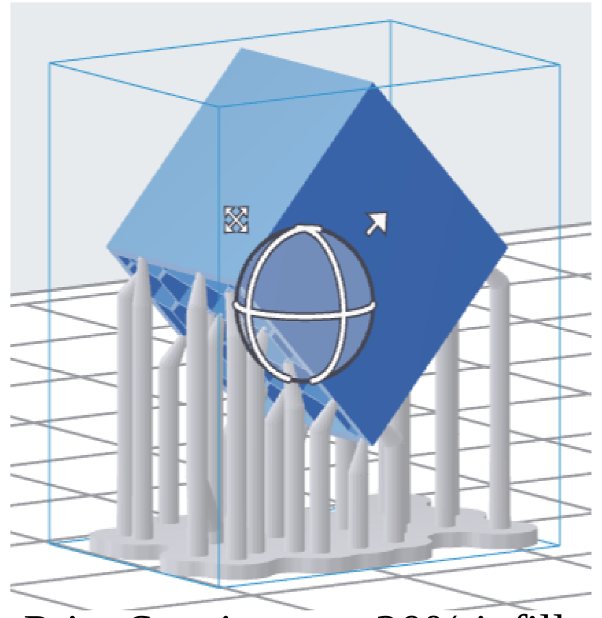
Model Design and Slicing

The Computer Aided Design (CAD) models for both types of 3D printing were developed using ANSYS SpaceClaim. While most slicing software includes the option to print with different print parameters (infill pattern, density), FormLabs' PreForm software for the Form2 SLA printer does not allow the user to add any infill. (Resin printing requires drainage holes/open surfaces to evacuate resin mid-print.) ANSYS SpaceClaim CAD software allows the user to shell entire surfaces and create infill at different patterns and percentages in the CAD model (as opposed to the slicer software).

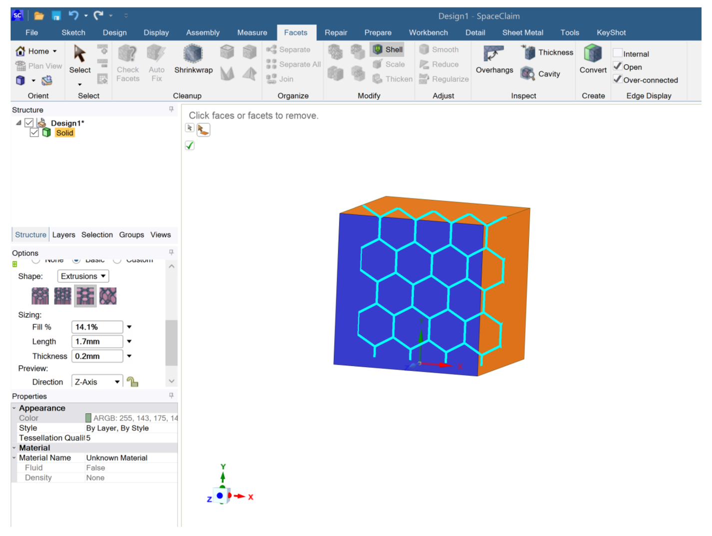
An Inside Look



Print specimen at 20% with honeycomb infill pattern on the ideaMaker slicing software for FFF printing.



Print Specimen at 20% infill with a hexagonal infill pattern on the PreForm slicing software for SLA printing.

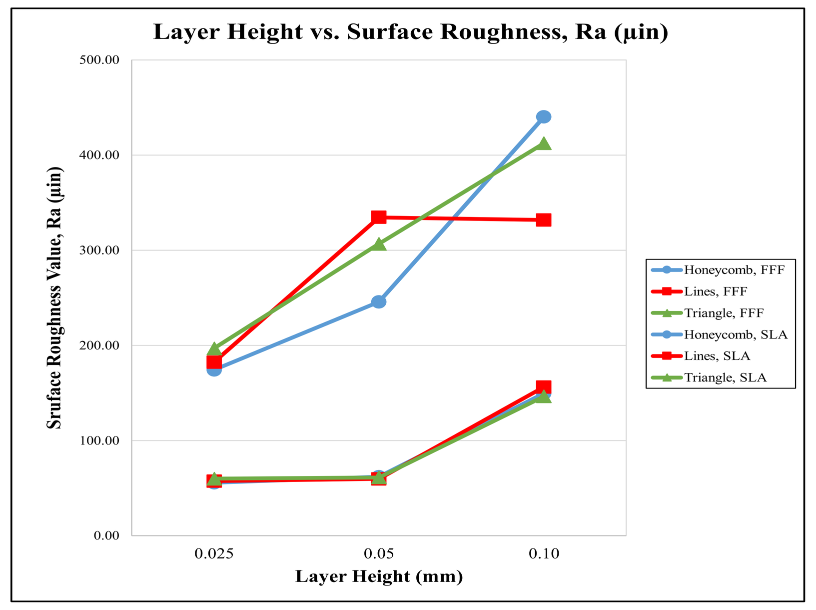


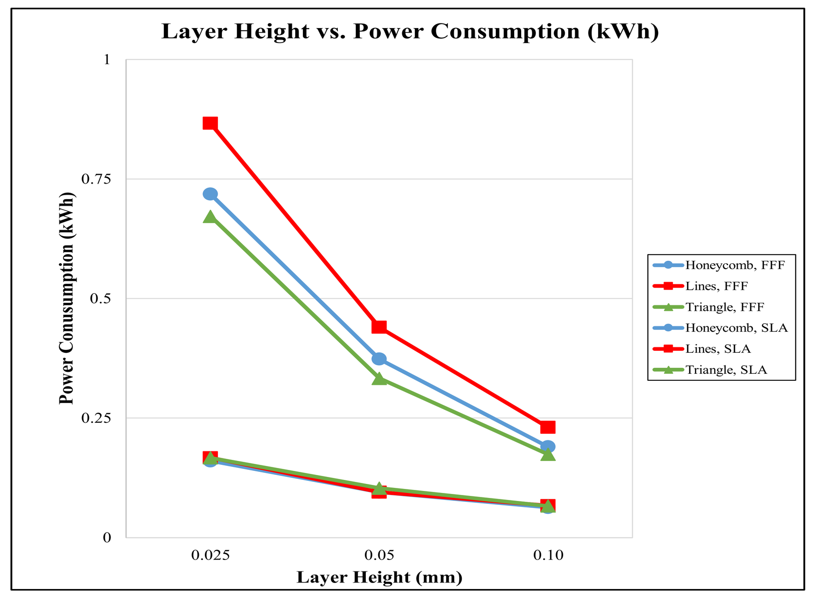
ANSYS SpaceClaim model showing shell and infill generation

Results

Predicted build time and actual build time for selected prints

Layer Height	Percentage	Infill Pattern	SLA Predicted Time	FFF Predicted Time	SLA Actual Time	FFF Actual Time
0.025	10	Triangle	4:04:00	2:31:26	3:42:10	2:34:10
0.05	10	Triangle	2:27:00	1:17:48	2:08:05	1:18:20
0.1	10	Triangle	1:34:00	0:40:06	1:21:25	0:38:15
0.025	10	Hex	4:04:00	2:24:39	3:42:30	2:33:20
0.05	10	Hex	2:26:00	1:14:25	2:07:05	1:17:15
0.1	10	Hex	1:34:00	0:38:26	1:18:35	0:38:05





Surface Roughness vs. Layer Height (top) and Power Consumption vs Layer Height (bottom)

Conclusion

The SLA process is shown to have marked improvements over FFF in power consumption and surface finish, while FFF is faster and less expensive per part.

Future Work

Future iterations of this project could focus on infill gradation, more complex geometry, and/or machine learning algorithms