Impact Testing of 3D Printed Polymers

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Objective

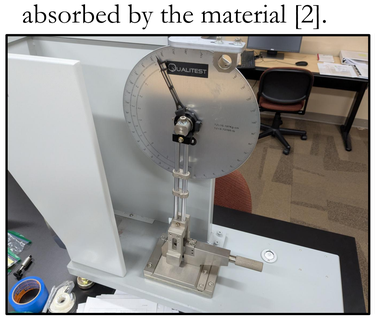
The purpose of this experiment is to characterize the effects that different slicer settings have on the ability of a 3D printed polymer to withstand impact. PLA and PETG material will be used for testing. The different slicer settings that will be tested are infill density, wall loops, and layer height. Testing will be conducted according to American Society of Testing and Materials (ASTM) D256 [1]. Each specimen will also be weighed, allowing for insight into how the amount of material present affects the impact resistance.

Abstract

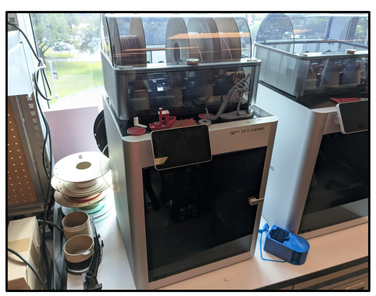
In this experiment, polyethylene terephthalate glycol (PETG) and polylactic acid (PLA) were tested for their impact resistance. The test specimens were produced from these materials via fused deposition modeling (FDM). This method of 3D printing involves heating the material filament and extruding it through a nozzle, building the part layer by layer.

Test specimens of each material were printed with dimensions according to ASTM D256 [1]. For each material, there was a control group, increased infill group, increased wall loops group, and a decreased layer height group. For each group, three specimens were tested. This gives a total of 24 specimens tested for this experiment.

Izod impact testing relies on the principle of conservation of energy. A pendulum is released from an elevated position and strikes the test specimen at the bottom of the stroke, causing the specimen to fail. The pendulum will then reach a new maximum height on its up-swing. The difference in height between the start and end position of the pendulum gives the energy absorbed by the material [2].

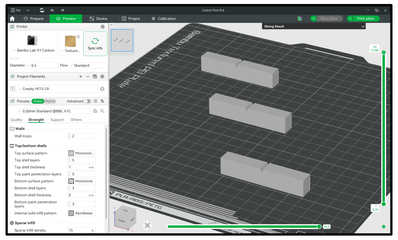


Qualitest Izod Impact Tester


Bambu X1 Carbon 3D Printer

Procedure

Test specimens were designed in Solidworks and exported as an STL file. The STL file was imported into the Bambu Studio slicer, where infill, wall loops, and layer height were modified. Three specimens of each type were produced, for a total of 24 samples. Finally, samples were placed in the Qualitest Izod tester for testing.


Bambu Studio Slicer Software

Results

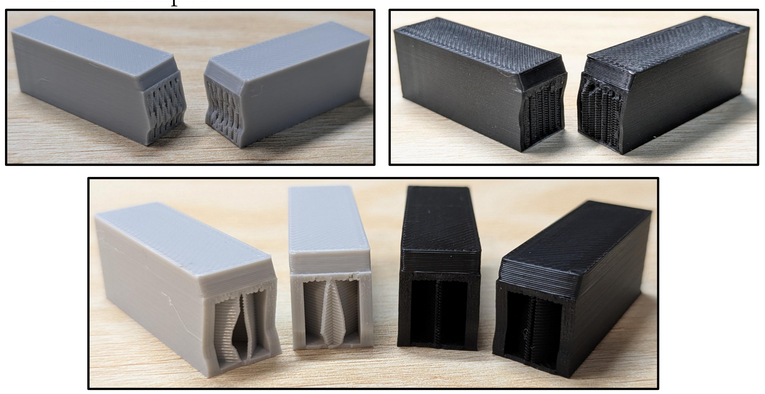
Using a two-sample *t*-test [3], it was determined that only the test specimens with a modified infill density absorbed significantly more energy than their respective control group. Although the average energy absorbed by specimens with increased wall loops was higher than the control, statistical analysis deemed this difference insignificant.

PETG (gray)	Energy Absorbed, average (J)	Mass, average (g)
Control	0.372	3.93
Infill Density, 80%	0.460	8.41
Wall Loops, 4	0.376	5.28
Layer Height, 0.01mm	0.372	3.94

PLA (black)	Energy Absorbed, average (J)	Mass, average (g)
Control	0.372	4.07
Infill Density, 80%	0.460	8.66
Wall Loops, 4	0.418	5.39
Layer Height, 0.01mm	0.375	4.04

Conclusion

Testing revealed that the specimen group with increased infill absorbed significantly more energy under impact than the respective control groups. Specimens with increased wall loops also absorbed more energy than the respective control groups, but this difference was deemed insignificant for this experiment. Layer height specimens showed minimal differences compared to control groups. Because of errors in this experiment, such as an oversized hammer, energy absorption values are not relevant. However, the data shows that slicer settings are capable of having a significant effect on a 3D printed part's ability to withstand impact.


Broken Test Specimens
Top left: PETG, 80% infill
Top right: PLA, 80% infill
Bottom left: PETG, 4 wall loops
Bottom right: PLA, 4 wall loops

References

[1] "Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics," American Society for Testing and Materials (ASTM), 2024.
[2] W. D. Callister, Materials Science and Engineering, Hoboken: Wiley, 2018.
[3] J. Devore, Probability and Statistics for Engineering and the Sciences, 9th Edition, Boston: Cengage Learning, 2016.
[4] Qualitest, "Izod Testing Operation Manual".