

Effect of Extrusion Temperature on the Overhang Angle Limit of a 3D Printed Figure

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Research Question

Although there have been many experiments in the broad field of 3D printing, there have been minimal experiments that test the overhang limit. In the past studies found, a higher extruder temperature (200°C-220°C) has usually allowed the figure to achieve the highest overhang angle.

The overall purpose of this experiment was to determine the effect of extrusion temperature on the overhang angle limit of a 3D figure. In simpler terms, how does temperature of the extruder affect the overhang angle, and what temperature allows the greatest overhang angle to be printed?

Research Question - Purpose and Hypothesis

I chose this project because I was given a 3D printer for my birthday. I became very interested and also received help from my friend who got me into 3D printing.

I hope to use the results of this experiment in my future experiments. When printing something that has a high overhang angle, supports are the default solution, but can make the end result look rough after they have been removed. If I can find the ideal temperature, then I may not have to use supports, and end with a cleaner result.

The hypothesis was as follows: the lower the extruder temperature is, the higher the overhang angle can be printed. Most of the research that led to these conclusions was from past experience working with 3D printers and problems that I have encountered. If the temperature is too hot, the plastic may drip down the side of the overhang before it cools, leading to a rough result.

Methodology and Procedures

The data collected was the angle reached before failure. This was collected using the angle markers printed onto the figure.

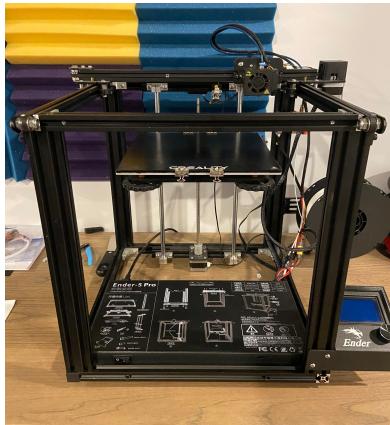
The variables tested were the five different extruder temperatures. The experiment had no control group, but the filament, file being printed, 3D printer, and bed temperature were kept the same throughout the tests. The experiment consisted of five tests. Each test, the same 3D file was printed but the extrusion temperature increased by 10°C each time, starting at 180°C and ending at 220°C.

The experiment was planned beforehand and did not need to be changed. I have been working with the 3D printer in a safe environment, no assistance was needed.

Images



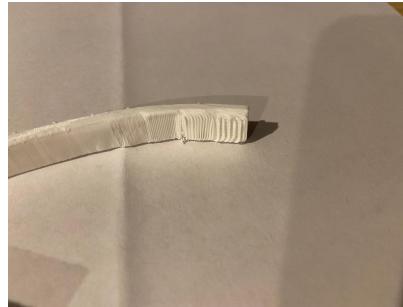
All tests



The 3D printer - Ender 5 Pro



Filament used - white PLA



180°C



190°C



200°C



210°C



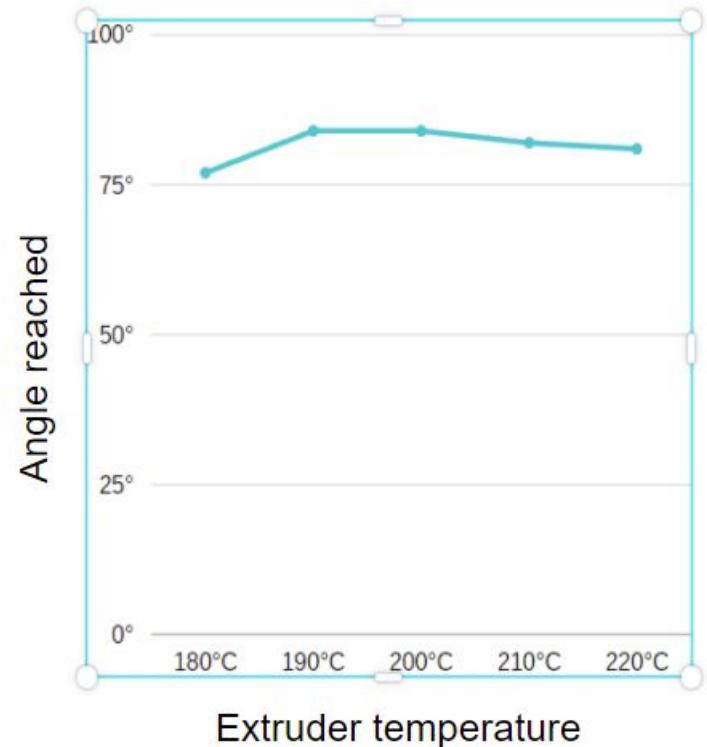
220°C

Results - Data

The effect of extruder temperature on the overhang angle reached

Temperature	Angle reached
180°C	77°
190°C	84°
200°C	84°
210°C	82°
220°C	81°

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Results - Interpretation

The results show that extruder temperatures of 190°C-200°C provide the highest overhang angle. A trend was observed, showing that the extruder temperature cannot be too much higher than or too much lower than ~195°C.

The experiment was fairly solid in that only one variable was changed and all the control variables were easy to maintain, leaving little room for error. The only hardship encountered was measuring the end results, but was solved in the end, and the results were tabulated and analyzed correctly.

There are some limitations of the data collected. The results only test the extruder temperature, and not other variables like bed temperature or type of filament. Another type of filament like ABS could greatly affect the overhang angle, although bed temperature is unlikely to affect the overhang limit since it only affects the bottom of the print.

Conclusion

The hypothesis, stating that the best temperature would be 180°C, was somewhat wrong because the final results showed that the ideal temperature is actually between 190°C and 200°C.

The experiment was also somewhat contradictory to past experiments done by others. The results of one past experiment showed that a higher temperature (205°C-220°C) had the most positive effect on the overhang limit. Those results are only marginally higher temperatures than my experiment. With that, it can be reasonably concluded that an extruder temperature anywhere from 190°C-220°C is acceptable and will provide the near-best, if not the best, final results.

Conclusion (cont.)

This work could be expanded by keeping the extruder temperature at the ideal temperature concluded from this experiment, but testing another variable like the type of filament. This can lead to much better results if all of the 3D printing parameters are ideal.

Hopefully, the results of this experiment can be used in my future experiments and further research, as well as other recreational purposes or industrial applications.

3D printing is a technology that could change the world sometime in the near future. Part of that near future is already here, with 3D printing technology being used more widely everyday in medicine, industry, and more!

References

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