

Research On Solutions To Slicing Errors In FDM 3D Printing Of Thin-walled Structures

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Abstract

The desktop-level 3D printing machines makes it easier for independent designers to produce collectible models. Desktop 3D printers that use FDM (Fused Deposition Modeling) technology usually use a minimum nozzle diameter of 0.4mm. When using FDM printers to make Gunpla models, Thin slice structures are prone to slicing errors, which lead to deformation of printed objects and reduction in structural strength. This paper aims to analyze the printing model that produces errors, control a single variable among the three variables of slice layer height, slice wall thickness and filament type for comparative testing, and find a way to avoid gaps. To provide assistance for using FDM printers to build models containing thin-walled structures.

Keywords: 3D printing , Fused deposition modeling , Modeling , Thickness , Gaps

1. Introduction

In the past, only large enterprises could use 3D printing technology for design and production, such as aerospace, automobile manufacturing, medical industry, clothing and accessories, etc. In the past five years, desktop-level 3D printers have gradually entered the market. Now the prices of FDM (Fused Deposition Modeling) and DLP (Digital Light Processing) technology 3D printers have dropped. As independent artists, it has become possible to use 3D printing for learning, research, design and production. Small companies can use desktop-level 3D printers to shorten product development cycles and reduce the cost of making samples.

Among desktop-level 3D printers, there are two main technologies: FDM and DLP. In comparison, the cost of machines and consumables using FDM technology is lower, and the production speed is faster. In the film and game industries, the sales of peripheral products derived from an IP (Intellectual Property) are increasing day by day. Using 3D printing technology to complete design, production and customization has become an emerging industry. When using an FDM printer to make models, due to the limitation of the nozzle diameter, the printed model has certain requirements on the structure of the model. Models with a thickness less than 2mm are prone to slicing and printing errors. This paper takes the hard surface model as an example and uses the method of controlling a single variable to study the reasons and solutions for errors in the vertical printing

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of the thin-walled structure of the model.

2. Related Research

2.1 Concept and Classification of 3D Printing Technology

3D printing is also called additive manufacturing, which is the opposite of traditional subtractive manufacturing [1]. 3D printing can create physical objects from a geometrical representation by successive addition of material [2]. According to ASTM Standard F2792 [3], ASTM catalogued 3D printing technologies into seven groups, including the binding jetting, directed energy deposition, material extrusion, material jetting, powder bed fusion, sheet lamination and vat photopolymerization. Desktop 3D printers currently on the market usually use FDM (belongs to one of the Materials extrusion types) technology or DLP (belongs to one of the Vat Photopolymerization types) technology. These two technologies make it easy to create lightweight machines, and the machines are cheaper to manufacture, making them suitable for use by small companies and independent artists. FDM was developed in early 1990 and this method uses polymer as the main material [4]. FDM builds parts layer-by-layer from the bottom to the top by heating and extruding thermoplastic filament. The operations of FDM are as follows: (1) Thermoplastic heated to a semi-liquid state and deposits it in ultra-fine beads along the extrusion path (Fig. 1). (2) Where support or buffering needed, the 3D printer deposits a removable material that acts as scaffolding. For example, FDM uses hard plastic material during the process to produce 3D bone model [5].

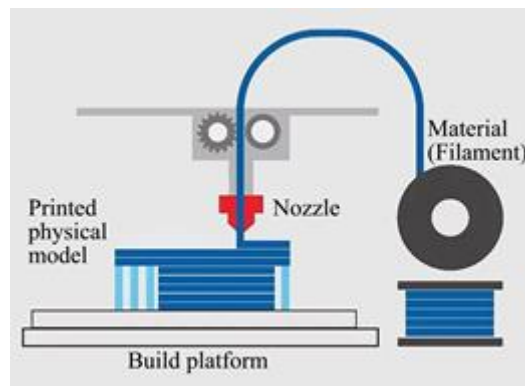


Figure 1. FDM principle

2.2 Relevant Paper Search

Through RISS (<https://www.riss.kr>), Google Scholar (<https://scholar.google.com>), CNKI (<https://www.cnki.net>). Search of three websites, no relevant research papers found.

3. Problem Analysis and Research Methods

3.1 Problem Analysis

When using the UltiMaker3 FDM technology 3D printer to print a 2mm thick structure perpendicular to the printing platform, it was found that the structure could not be filled normally (Fig. 2). The printer nozzle diameter was 0.4mm and white PLA filament was used. This will create gaps in the middle of the physical model, resulting in reduced structural strength and thickness deviations [6]. After replacing other models with

similar structures for testing, the same gap was found (Fig. 2). Analyze the reasons that may affect the above results: thickness of the model structure, slice layer height [7], slice wall thickness and filament material [8].

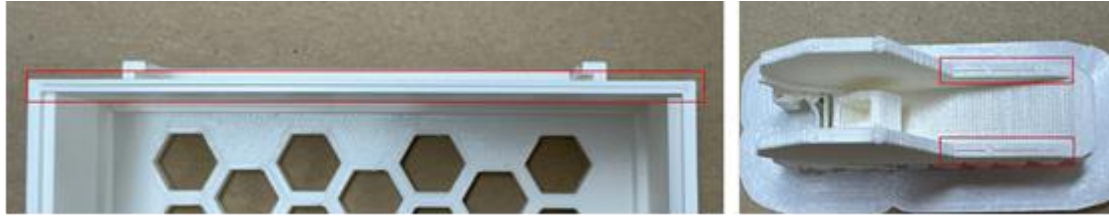


Figure 2. Fill error

3.2 Research Methods

First, use the "3dsMax2023" software to make a test model. The test model includes two structures, cuboid and cylinder, perpendicular to the printing platform. Use the "UltiMaker Cura5.4.0" software for slicing. Use the "UltiMaker3" 3D printer to print the test model, and the filament is "UltiMaker PLA Material". Compare the printing effects of different thicknesses to find the structure and thickness where gaps will appear. (Fig. 3)

Analyze printing models where errors occur, control a single variable among the three variables - slice layer height, slice wall thickness and filament type - for comparative testing and find ways to avoid gaps.



Figure 3. Process of Experiment

4. Experimental Process and Results

4.1 Model Structure and Thickness Testing

Make cylinder and box with rounded corner models (Fig. 4). The slicing parameters are: layer height 0.15mm, wall thickness 0.8mm, printing speed 80mm/s, print the physical model (Fig. 4). The test results are: the cylinder will not produce gaps, only the rectangular structure and the thickness is 2mm will produce gaps.

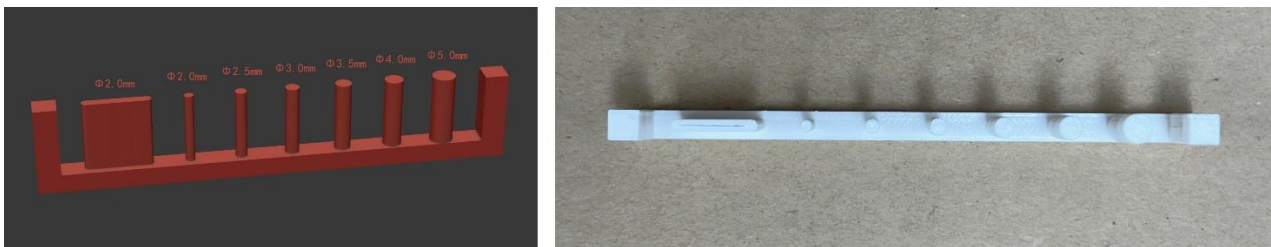


Figure 4. Modeling A and Physical model A

Make models of cuboid structures with different thicknesses again (Fig. 5), and use the same slicing

parameters to print the physical model (Fig. 5) The test results are: when 2.0mm and 1.5mm thick cuboid-like structures are printed perpendicular to the printing platform, gaps will occur.

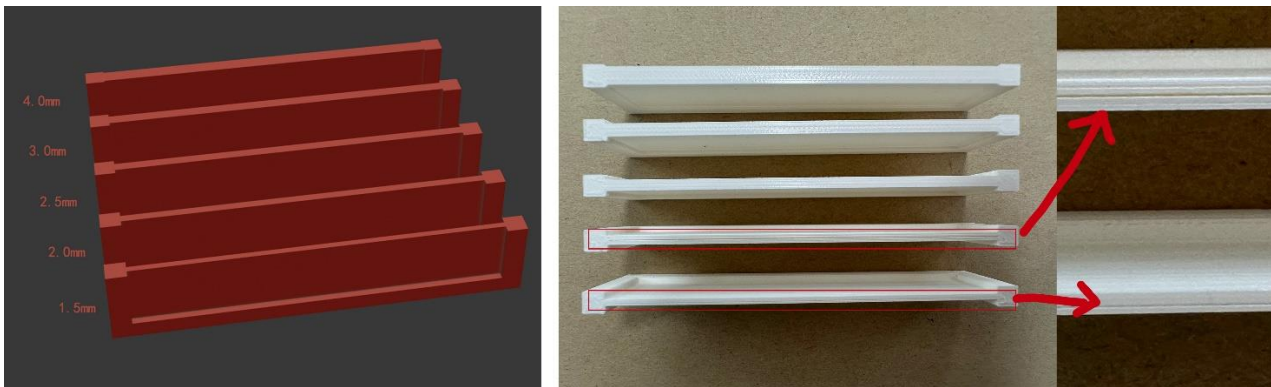


Figure 5. Modeling B and Physical model B

4.2 Slice Layer Height Test

Use a 2.0mm thick cuboid model to re-slice, modify the layer height to 0.10mm (usually lowering the layer height will increase the printing time, but it can avoid printing errors), keep other variables consistent, and print the physical model again. The test results are: Layer There is no difference in the printed physical model between the slicing parameters of 0.10mm height and 0.15mm layer height (Fig. 6) The slice layer height does not affect the generation of gaps.



Figure 6. Physical model C

4.3 Slice Wall Thickness Test

Use the 2.0mm thick cuboid model to re-slice and modify the wall thickness to 1.2mm. When previewing in the "UltiMakerCura5.4.0" software, you can find that there is one more line of paths than when the wall thickness is 0.8mm (Fig. 7). Keep other variables constant, and print the physical model again. The test results are: when the wall thickness increased by 0.4mm (nozzle diameter), there would be no gaps in the printed physical model (Fig. 7).

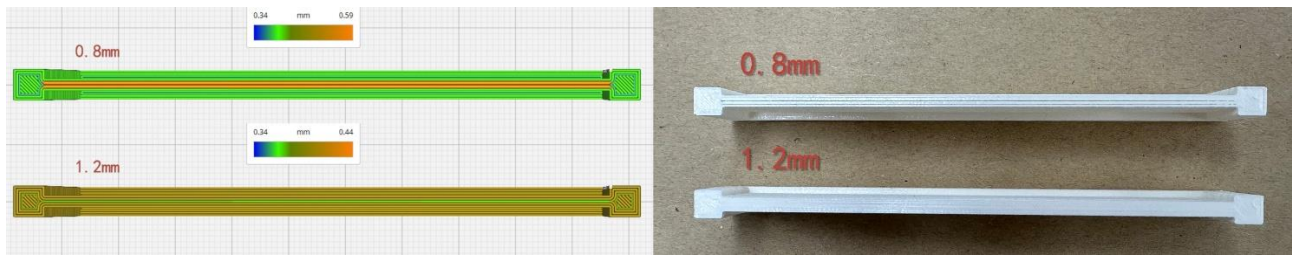


Figure 7. Slice preview and Physical model D

4.4 Filament Material Testing

Use a 2.0mm thick cuboid model, and the slicing parameters are: layer height 0.15mm, wall thickness 0.8mm, printing speed 80mm/s. Use the same slice file and replace the PETG material filament to print the physical model, The test results are: PLA filament and PETG filament will produce the same gap. Because PETG material is transparent, a white 0.1mm thick sheet is inserted into the gap to make the picture more obvious (Fig. 8). The material of the filament Does not affect the creation of gaps.



Figure 8. Physical model E

5. Conclusion

To sum up, when a cuboid-like thin-walled structure smaller than 2mm is printed perpendicular to the printing platform, there are two solutions to avoid gaps in 3D printed physical models (Table 1):

- During the model making stage, it is expected that the thickness of the structure that may be printed perpendicular to the printing platform should be greater than 2.0mm. The disadvantage of this method is that it limits the thickness of the model. The advantage is that there is no need to modify the slicing parameters separately after the model is completed, making it easier to share files.

- During the slicing stage, increase the wall thickness in the slicing parameters (called ‘Wall Line Count’ in some slicing software). The disadvantage of this method is that the wall thickness of all parts in the same slicing file will increase, the mass will increase, and more materials will be used, takes longer, and has the advantage of being able to 3D print a perfect physical model without limiting the structural thickness of the model.

Both methods can solve the problem of creating gaps raised in this paper, and can be selected according to the actual situation of the project. If the structural thickness of the model perpendicular to the building platform

is greater than 2mm, there are still gaps, then try to increase the “Wall Line Count by” 1.

Table 1. Test results

Model number	Shape	Model thickness (mm)	Printing layer height (mm)	wall thickness (mm)	Material	GAP
A	Cylinder	2.0	0.15	0.8	PLA(White)	NO
A	Cylinder	2.5	0.15	0.8	PLA(White)	NO
A	Cylinder	3.0	0.15	0.8	PLA(White)	NO
A	Cylinder	3.5	0.15	0.8	PLA(White)	NO
A	Cylinder	4.0	0.15	0.8	PLA(White)	NO
A	Cylinder	5.0	0.15	0.8	PLA(White)	NO
B	Box	1.5	0.15	0.8	PLA(White)	YES
B	Box	2.0	0.15	0.8	PLA(White)	YES
B	Box	2.5	0.15	0.8	PLA(White)	NO
B	Box	3.0	0.15	0.8	PLA(White)	NO
B	Box	4.0	0.15	0.8	PLA(White)	NO
C	Box	2.0	0.10	0.8	PLA(White)	YES
D	Box	2.0	0.15	1.2	PLA(White)	NO
E	Box	2.0	0.15	1.2	PETG(Transparent)	YES

The thin wall structure of the 3d printed model is easy to break. When building with desktop-level FDM 3D printer, because the thickness is too small to produce a filling layer, so it often produces calculation errors in slicing software. This correction method can ensure that the printed physical model has strong structural strength. Effectively avoid dimensional deviation and insufficient structural strength caused by abnormal printing lines.

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