

FDM

3D Filament Application Recommendation White Paper

Introduction

This recommendation aims to establish Flashforge FDM material technology system, and provide suitable 3D printing materials for customers when using Creator 4 or other professional equipment, so as to improve printing efficiency and quality.

We divide the material requirements into the following four categories:

- 1 Model Appearance Verification** ---- 01
PLA, ABS, HIPS and other standard materials
- 2 Function Application** ----- 05
PBT, PC, PA, PAHT and other engineering materials
- 3 High-performance Lightweight Finished-product** --- 09
PA12-CF, PET-CF and other fiber reinforced materials
- 4 Flexible Finished-product** ----- 13
TPU and other rubber and silica gel materials

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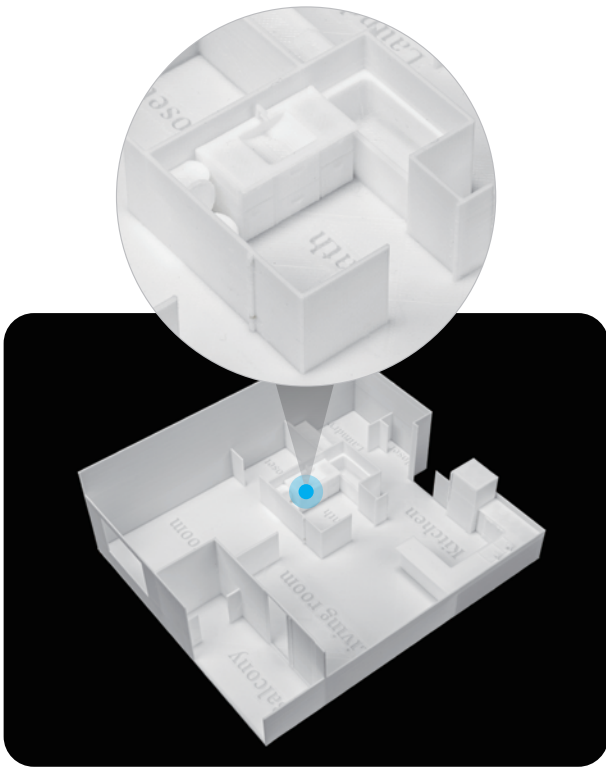
Model Appearance Verification

PLA, ABS and HIPS are all excellent choices for customers in the early phase of model verification, and can achieve better surface quality. However, due to the different complexity and performance requirements of various models, we recommend that customers choose the suitable material for printing according to the specific working conditions for the model.

Good Comprehensive Performance	ABS	ABS+HIPS
Heat Resistance (80°C)	ABS/HIPS	HIPS+ABS ABS+HIPS
No Heat-resistance Requirement	PLA	HIPS+ABS
Model Requirements	Simple (little or no support)	Complex (multiple supports)

PLA

PLA is one of the earliest materials used for 3D printing, and it is the most widely used thermoplastic material for FDM printing equipment at present. It has low cost, high formability, good appearance result, biological degradability and other characteristics. Its low melting point allows for rapid printing at low temperatures, and it is not prone to warping during printing, making it very suitable for early concept modeling and quick prototyping. However, it is not suitable for printing industrial and outdoor parts due to its poor temperature resistance, low UV resistance and weaker layer adhesion compared to other materials.



Layer height: 0.18mm
Printing temperature: 200°C
Printing speed: 60mm/s
Type of support: Self-support or water-soluble support

PLA-CF



PLA-CF is a composite material with a certain content of carbon fiber added in PLA, so it provides better heat resistance and mechanical properties. The printed model features a bright luster, and the model support is easier to remove.

ABS

ABS is one of the five top general thermoplastics with high tenacity and temperature resistance. The surface of the model printed with ABS material is smooth, delicate and flat, and of excellent quality. It is the material offering the most beautiful appearance among FDM thermoplastic printed models, making it ideal for the prototyping of small household appliances, mechanical parts such as LEGO bricks, automotive parts and cellphone parts, and rapid prototyping design verification.

The ABS material used in this paper has relatively poor layer adhesion, so it is not recommended to use it to print small columnar structures or thin-walled parts.

Layer height: 0.18mm

Printing temperature: 240°C

Printing speed: 50mm/s

Type of support: Self-support or HIPS



HIPS



HIPS is a thermoplastic resin with low hydroscopicity. It possesses no odor, good glossiness, good mechanical properties and molding stability, and is easy to be attached to a print surface. It has the same-level heat resistance as ABS, and its layer adhesion is better than ABS, making it more suitable for printing thin-walled parts.

Layer height: 0.18mm
Printing temperature: 250°C
Printing speed: 50mm/s
Type of support: Self-support or ABS

PETG / PETG-CF



For exterior parts, Flashforge PETG and PETG-CF provide high glossy surface quality and good UV resistance, and are suitable for printing some simple outdoor models.

2 Function Application

PBT, PC, PA and PAHT are commonly used engineering materials with excellent heat resistance and chemical resistance, and can still maintain excellent mechanical properties in a wide temperature range, making them suitable for being used as structural materials.

PBT

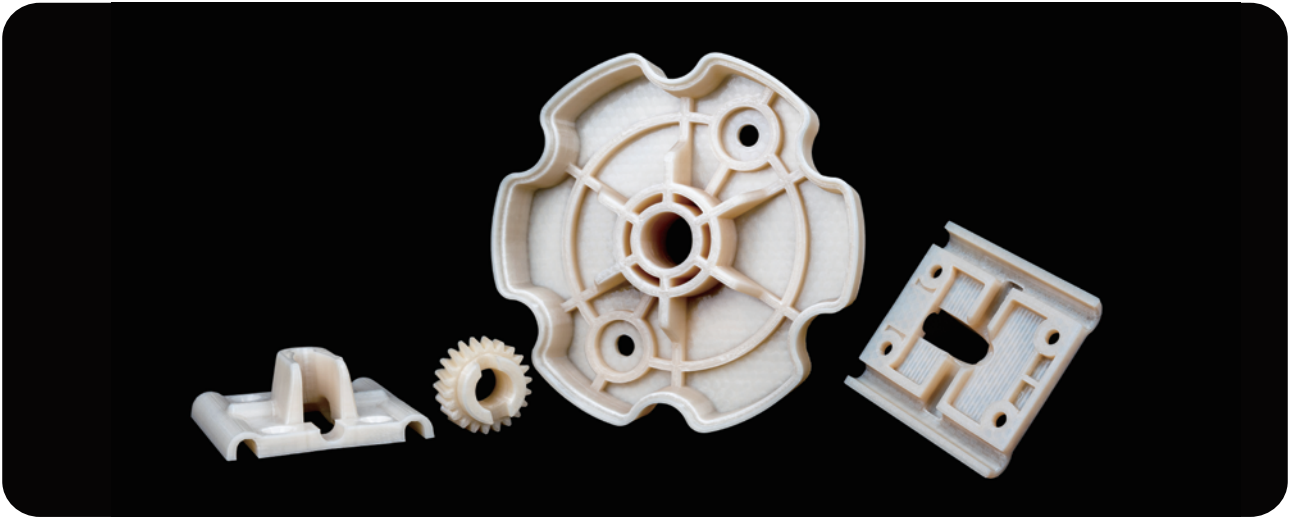


PBT has good processing fluidity, low moisture absorption, excellent heat resistance, excellent electrical properties, excellent Z-direction tensile strength and other characteristics. The surface of the finished-product is of matte texture, with good layer adhesion and tenacity, and has a very good bonding effect on the thin-walled bonding surface, which makes it suitable for printing thin-walled parts and small columns. It can be applied to printing fine parts, such as fasteners, electronic appliances, pins and other matching inserts.

Drying condition: 80°C for 8hrs
Layer height: 0.18mm
Printing temperature: 240°C
Printing speed: 50mm/s
Type of support: Self-support or water-soluble support

Before printing, it is recommended to put the material to be printed into Flashforge Filament Drying Station for dehumidification and drying. If the raft can not be easily separated from the model, you can place the model raft on the 80°C platform to be heated for 3 minutes.

PA

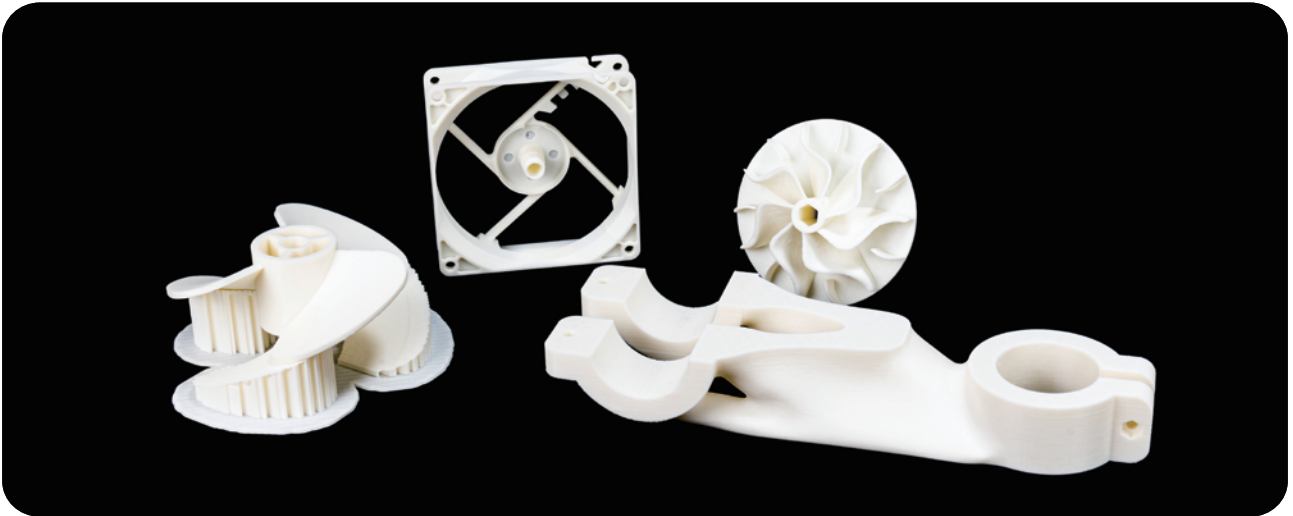


PA features high tensile strength, wear resistance, light specific gravity and excellent lubricity, etc. The surface of the finished-product is smooth, and it has excellent heat resistance and chemical resistance, and its tenacity is better than PAHT. It is suitable for printing pump impeller, valve seat, bearing, instrument panel, air regulating valve and other parts.

PA material is susceptible to moisture. Before printing, it is recommended to put the material to be printed into Flashforge Filament Drying Station for dehumidification and drying. Dry storage is required after printing.

Layer height: 0.18mm
Drying condition: 80°C for 10hrs
Printing temperature: 250°C
Printing speed: 45mm/s
Type of support:
Water-soluble support

PAHT



Like other polyamide materials, PAHT also has good chemical resistance, especially good resistance to oil and grease at high temperatures. In addition, the high crystallinity of PAHT makes it maintain excellent mechanical properties at high temperatures ($> 150^{\circ}\text{C}$), which makes it an ideal engineering material for heat-resistant parts in the automotive (engine covers, air intake devices, etc.) and electronic/electrical industries (connectors, power connectors, etc.).

Drying condition: 80°C for 8hrs
Layer height: 0.18mm
Printing temperature: 265°C
Printing speed: 50mm/s
Type of support: Self-support

PC



PC has extremely high impact-resistance strength and high heat deflection temperature. The finished-product has good glossy surface, excellent mechanical properties, low warpage, and good layer adhesion, and can work for a long time in an environment above 100°C. It is suitable for making small instrument parts, impact-resistant automotive parts or high-performance parts in some aerospace fields.

Drying condition: 80°C for 8hrs
Layer height: 0.18mm
Printing temperature: 255°C
Printing speed: 50mm/s
Type of support: Self-support

PP



PP is one of the lightest materials because of its low relative density. It possesses excellent mechanical properties and heat resistance. The surface of the PP-printed part in this paper is matte and frosted, with high impact resistance and corrosion resistance. The higher heat resistance makes it possible to be used in a higher-temperature environment. It is widely used in the fields of ventilation pipes and auto parts.

Layer height: 0.18mm
Printing temperature: 250°C
Printing speed: 50mm/s
Type of support: Self-support

PP printing requires a special platform film, so it is recommended to use PP film as the platform sticker for printing.

3

High-performance Lightweight Finished-product

PA12-CF



PA12-CF is a composite material with carbon fiber added in PA. Carbon fiber has the characteristics of high strength, low density and high temperature resistance, which greatly improves the mechanical properties, lightweight feature and dimensional stability of PA12-CF. The surface of the finished-product is matte and frosted. It is suitable for application parts with higher requirements for mechanical properties and heat resistance, as well as thin and light parts.

PA12-CF material is susceptible to moisture. Before printing, it is recommended to put it into Flashforge Filament Drying Station for dehumidification and drying. Dry storage is required after printing.

Drying condition: 80°C for 12hrs
Layer height: 0.18mm
Printing temperature: 280°C
Printing speed: 60mm/s
Type of support: Self-support

PAHT-CF/GF



PAHT-CF/GF is produced using high-temperature nylon material with 15% carbon fiber or glass fiber added, which greatly improves the mechanical strength and heat resistance of the material. After annealing at 100°C for 8 hours, the tensile strength of the part printed with PAHT-CF filament can reach 100Mpa, making it very suitable for printing samples under high temperature.

In addition, as this type of filament is susceptible to moisture, PAHT-CF/GF needs to be placed in a drying box with the air humidity lower than 13% when printing.

Drying condition: 100°C for 8hrs

Layer height: 0.20mm

Printing temperature: 295°C

Printing speed: 50mm/s

Type of support: Self-support or easy-to-remove support

Feature: Matte and frosted surface of the finished-product

PET-CF



PET-CF is a carbon fiber reinforced polyethylene terephthalate (PET). PET resin has a high glass transition temperature, good creep resistance and fatigue resistance, and high surface hardness, making it suitable for parts subjected to long-term stress. The mechanical strength and heat resistance of parts printed with carbon fiber added PET material are better than those of PA12-CF.

PET is a plastic material with very low water absorption but is extremely sensitive to moisture. PET-CF requires a dry box with air humidity below 10% when printing.

Drying condition: 120°C for 5hrs

Layer height: 0.18mm

Printing temperature: 300°C

Printing speed: 60mm/s

Type of support: Self-support

Feature: Matte and frosted surface of the finished-product, easy self-support removal

ABS-GF



ABS-GF is a low-odor ABS-based filament specially developed for 3D printing. The added 10% (mass fraction) glass fiber not only effectively enhances the tensile strength of ABS, but also improves its heat resistance. Compared with similar filaments, it has excellent dimensional stability. It is suitable for functional prototypes, fixtures and small-batch production parts.

Drying condition: 80°C for 8hrs
Layer height: 0.18mm
Printing temperature: 250°C
Printing speed: 50mm/s
Type of support: Self-support or easy-to-remove support
Feature: Matte and frosted surface of the finished-product

4

Flexible Finished-product

TPU



Thermoplastic elastomer TPU is a polymer material between rubber and plastic. It has the flexibility and elasticity that traditional thermoplastic materials can hardly achieve. It is widely used in the fields of shoe uppers, insoles, flexible hoses and seals.

TPU85A, TUP90A and TPU95A materials can all be applied to Creator 4. The main difference between these materials lies in the Shore hardness, among which TPU85A is the best in softness and TPU95A is the best in tear-resistance strength.

Layer height: 0.21mm
Printing temperature: 200°C
Printing speed: 45mm/s
Type of support: Self-support

Material Post-processing

The PA-based materials (PAHT/PA12-CF) introduced in this paper can be annealed in Flashforge Filament Drying Station after finishing printing to improve the mechanical properties of samples.

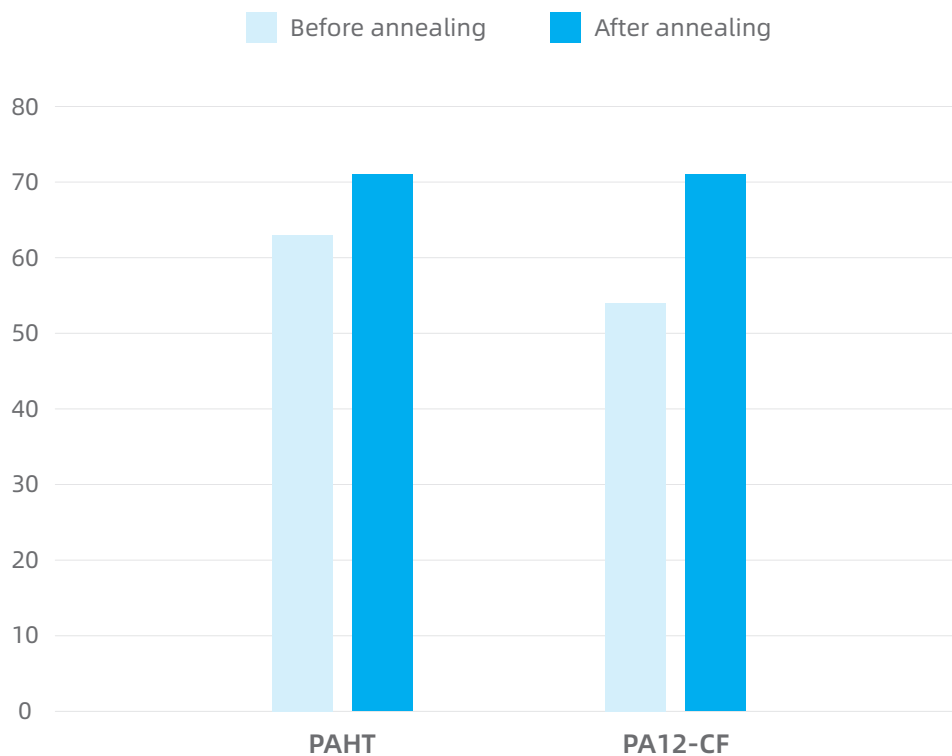
Annealing condition:

PAHT: Place the sample in Flashforge Filament Drying Station at 70°C and dry it for 2 hours.

PA12-CF: Place the sample in Flashforge Filament Drying Station at 80°C and dry it for 6 hours.

*Note: During annealing, the sample should not be in direct contact with the metal frame, but it can be placed on a pallet or a wooden board.

Comparison of tensile properties of PAHT and PA12-CF before and after annealing (Mpa)



Brief Description of Material Characteristics

The materials introduced in this paper all have unique characteristics, such as heat resistance, chemical resistance, wear resistance, excellent mechanical properties, high Z-axis layer adhesion. Customers can quickly verify and mass manufacture the models according to their own environment and working conditions.

Material		Characteristics
Standard Filament	PLA	High formability, degradability
Composite Filament	PLA-CF	Easy support removal
Standard Filament	ABS	Good comprehensive performance
Standard Filament	HIPS	High stiffness, high dimensional stability
Standard Filament	PETG	UV resistance
Engineering Filament	PBT	Low hydroscopicity, strong layer adhesion
Engineering Filament	PA	Self-lubrication, chemical resistance
Engineering Filament	PAHT	Temperature resistance, chemical resistance
Engineering Filament	PC	High tenacity, temperature resistance
Standard Filament	PP	Food safe, temperature resistance, chemical resistance
Composite Filament	PA-CF/GF	Temperature resistance, high strength, low warping
Composite Filament	PET-CF	High strength, low creep, fatigue resistance
Flexible Filament	TPU	Chemical resistance, low warping

- For the manual model with requirements for basic mechanical properties, it is recommended that users use ABS as the material for printing the model and use HIPS as the material for printing the support. ABS self-supporting can be used for printing parts with simple structure and not involving many supports.
- For finished-products with requirements for high mechanical properties and easy support removal, PA-CF/GF, PET-CF or PAHT can be used for printing; PBT should be used instead of PA when there are requirements for high-temperature resistance or the mechanical isotropy in three different orientations.
- PP and PA-CF can provide good heat resistance and chemical resistance besides producing light and thin parts (density < 1).

Note: The materials described in this paper are actually tested with Creator 4, and are recommended to customers as a priority. The application of materials is not limited to the filament brands, and the specific material trademark can be found in the slice configuration.



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