



White Paper

Introduction to Fused Filament Fabrication
(FFF) 3D printing technology

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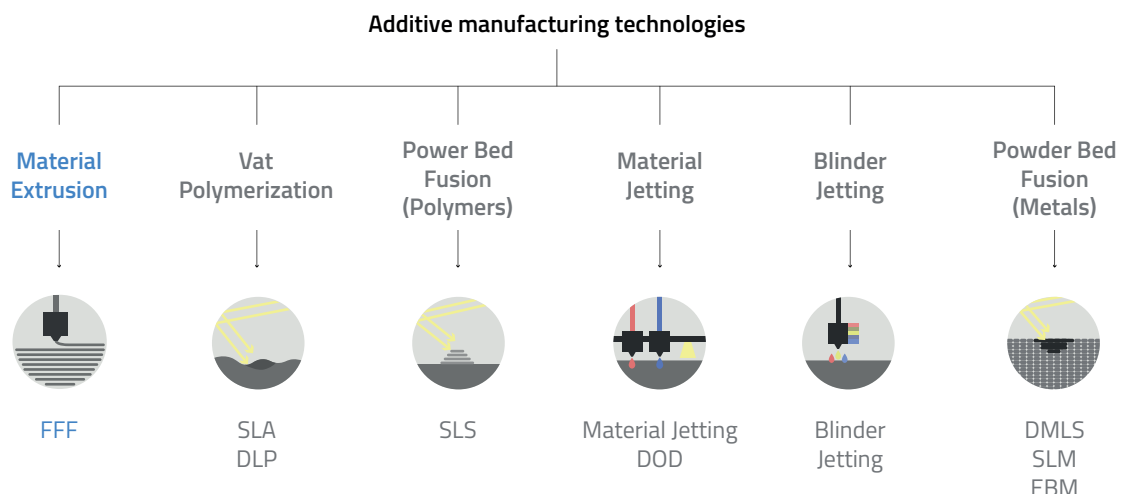
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Introduction to FFF: Fused Filament Fabrication

01

3D Printing Technology, technically acknowledged as Additive Manufacturing (AM) or Rapid Prototyping, is a manufacturing process where layers of material are built up to create a solid object. There are countless 3D printing technologies, each with its own benefits depending on the application, but this report will focus on Fused Filament Fabrication (FFF) for plastics.



How does FFF work?

How does FFF work?

02

As previously introduced, FFF consists of an extrusion process of melted plastic. In order to generate the part, a print head travels around the printing surface depositing the material. Here is the FFF fabrication workflow:



Figure 3. Workflow 3D printing

- The first stage consists of generating the 3D model with any design software, such as Solidworks, Catia, Rhino or Inventor. The 3D model needs to be exported in STL format.
- File preparation: To configure the model to be printed, it is necessary to use a slicing software where all the printing requirements will be included. This configuration will contain the material selection and the nozzle size of the printer. The software also separates the model into layers and the printing quality, and movement commands can be configured.

How does FFF work?

- The printing phase is the deposition of the melted plastic and consists of 3 stages:
 1. A filament spool is loaded into the printer. The nozzle has to reach the melting temperature of the raw material and then the filament is fed into the print head, where it will be melted.
 2. The print head is able to move over the printing surface in the X, Y and Z directions. It deposits the plastic to create a thin layer, cooling down the filament until it finally solidifies.
 3. When the previous layer is finished, the printing surface moves down and the next layer is deposited. This process is repeated until the model is completed.

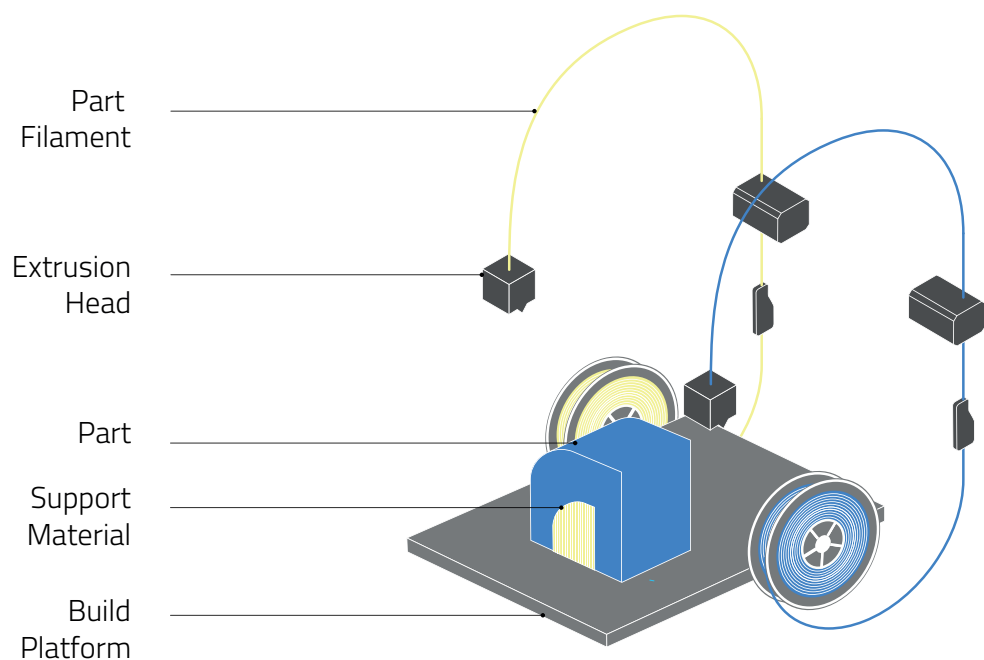


Figure 4. Basic illustration of a desktop 3D printer

Because of the manufacturing strategy, sometimes it is required to build auxiliary support structures for those models with overhangs shallower than 45° from the horizontal plane. A secondary extruder with a different material is dedicated to create this support structures.

Professional desktop vs industrial 3D printers

04

The FFF technology market, has different printer categories in relation to price and printing quality. In this section, the focus will be to compare Professional Desktop Printers and Industrial FFF Printers.



	 Professional Desktop Printers	 Industrial FFF Printers
Project Lead Time	<24 hours	<24 hours
Initial Cost	2.500€ - 7.500€	40k€ - 250k€
Material Cost	~25€/kg	~125€/kg
Print Cost vs Professional Desktop Printers	1x	5x
Costs: Long Term	Basic machine maintenance	Mandatory service contract (~10k€)

Figure 6. Comparison table - Professional desktop vs industrial 3D printers

• Costs

The initial investment makes the first significant difference between both types of printers, as the price of an Industrial FFF Printers is at least 20 times the price of a Professional Desktop Printer. Material costs are lower the latter and maintenance costs evidently lower as the purchase of an industrial FFF printer includes mandatory service contract.

Professional desktop vs industrial 3D printers

- **Lead Times**

The leading times are approximately the same. Both machines are limited by the FFF technology. An Industrial FFF Printer can handle high number of models in a single print job due to its massive printing volume. Some Professional Desktop Printers can reduce lead times using high-productive printing modes. These modes can print two identical parts or one part and its symmetrical simultaneously, doubling the productivity.

- **Accessibility**

Professional desktop printers can be used by anyone, as their setup and use are intuitive. The interaction with the machine is simple and prepared for non-expert users, including guided and detailed assistants. Since the use of an industrial printer is normally more complex, it requires specialized technicians and dedicated workspaces.

- **Quality**

Thanks to their controlled environment throughout the machine, Industrial FFF Printers offer a higher degree of accuracy than professional desktop printers. However, the level of detail that can be achieved is similar. Using different nozzles sizes, professional desktop printers can adapt to any part or geometry, ranging from complex details to rough, big prints.

Finally, the available range of loadable materials for Professional Desktop Printers is wide, as they often accept filaments from other manufacturers. Industrial Printers do not offer a broad range of filaments, as they only accept certain materials to minimize interference and ensure the quality standard of the end result.



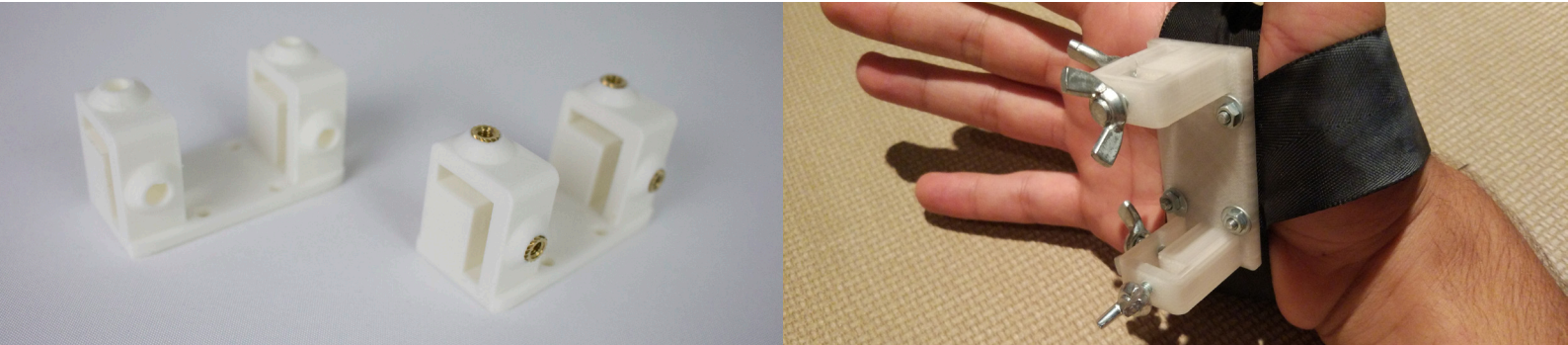
	 Professional Desktop Printers	 Industrial FFF Printers
Standard Accuracy	± 0.20 mm	± 0.15 mm
Layer Thickness Range	0.05-0.5 mm (depending on the nozzle diameter)	0.15-0.5 mm (depending on the printer)
Printing Surface	Medium	Large
Common Materials	PLA, ABS, PETG, TPU, PA. Accepts filaments from other manufacturers	ABS, PC, ULTEM. Only filaments accepted by the manufacturer

Figure 7. Quality comparison table - Professional desktop vs industrial 3D printers

Outsourcing 3D printing production

- **Example: uHandle**

In order to analyze when it is necessary to outsource the production, the case of uHandle is going to be introduced. uHandle is a company that tries to help leprosy patients on its daily life avoiding stigmatization, developing tools and other devices that will assist them in their daily needs. Although leprosy can be cured, this illness affects poor countries with no resources to treat the patients in a proper way. This disease affects the skin and the external nervous system, causing deformation in hands and feet. It is very important to facilitate the production of customized devices and tools to help these patients.



In this case, the studied tool aims to help the patient to hold cutlery, making them more autonomous to eat improving feeding and patients' self-esteem. The price of producing this part with a Professional Desktop Printer is 0,50€ while outsourcing it would cost approximately 15€. The following figure compares both options.

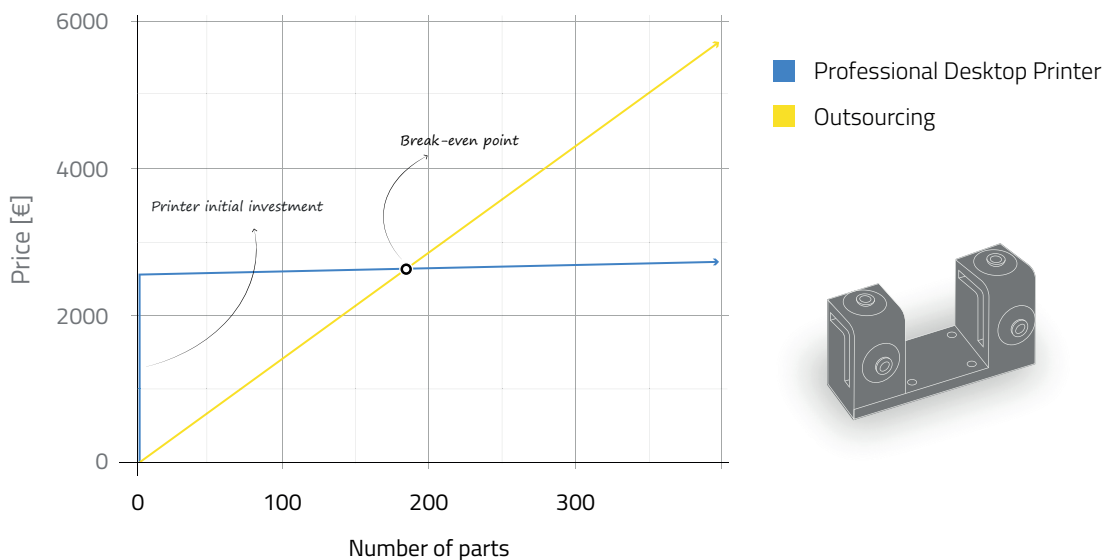


Figure 9. Production parts comparison graph - Professional desktop 3D printer vs Outsourcing

Should the number of parts to be produced had been under 180, outsourcing the production would have been the best solution in terms of costs. However, the goal was to produce at least 300 units of the device. Based on this, uHandle decided to invest in a Professional Desktop Printer to obtain long term benefit.

Additionally, using its own printer, uHandle could also develop the product with several iterations in order to fully optimize the design. By purchasing its own in-house Professional Desktop Printer uHandle gained flexibility. The company was able to develop the product observing several iterations and was able to fully optimize and tailor the end design.



About BCN3D technologies

BCN3D Technologies is one of the leading manufacturers of desktop FFF 3D printers worldwide.

Based in Barcelona, the activity of BCN3D began in 2012 and its aim is to help innovators and creatives to change the world, by offering them the best possible experience to materialize their unique ideas.

bcn3dtechnologies.com

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