UltiMaker guide

The 2024 carbon fiber 3D printing applications guide

Contents

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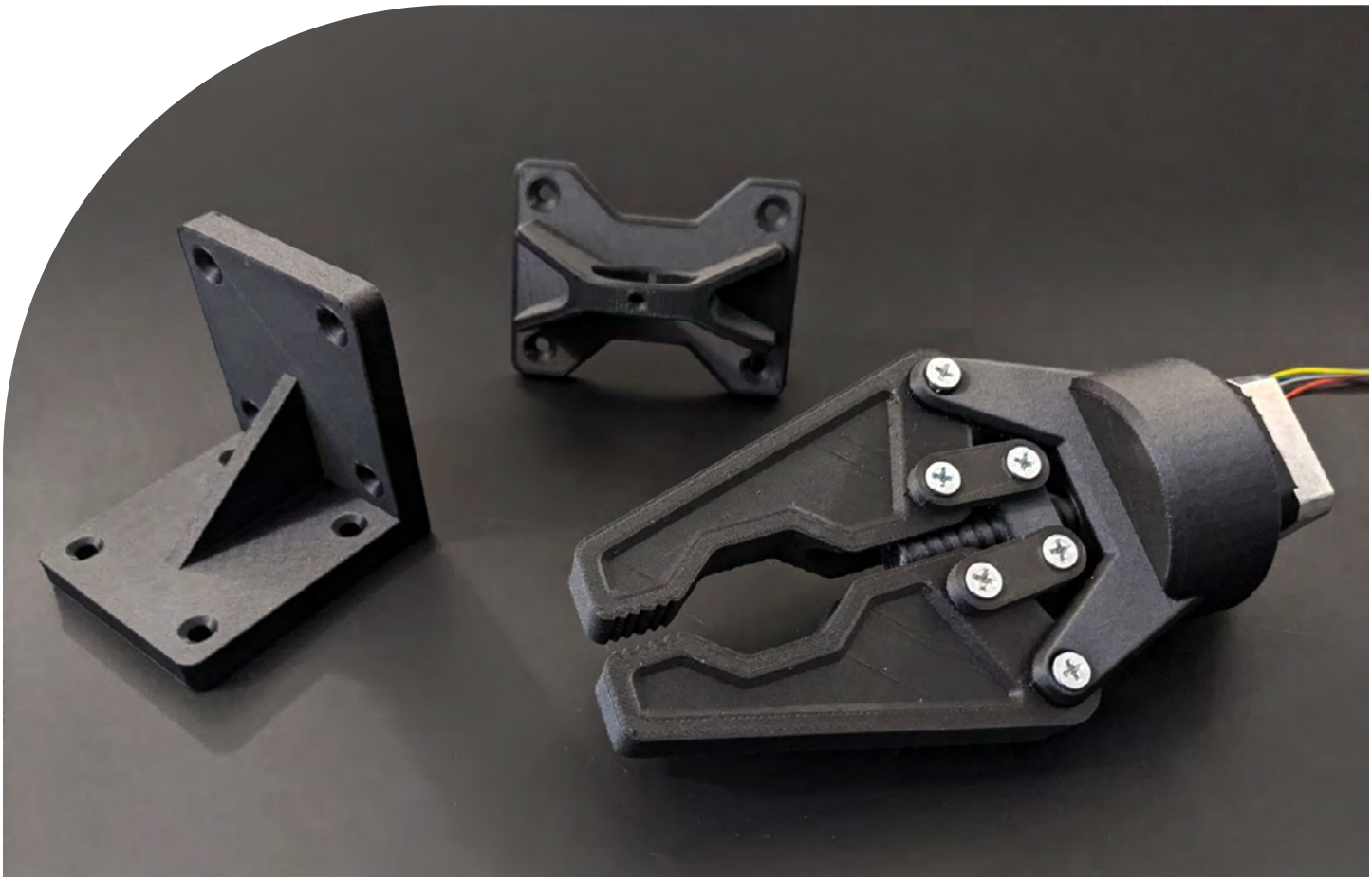


Introduction

If you're new to 3D printing, you're probably discovering the range of materials that are available. One of the most exciting material groups is composites, which include carbon fiber, a highly versatile material.

But what can you actually do with 3D-printed carbon fiber composites and when should you use them? This guide is designed to help answer that question.

Carbon fiber was first used by Thomas Edison in the late 19th century for use as a filament in early lightbulbs. In the late 1950s, the Union Carbide Corporation first realized the strength benefits that could be achieved through further processing techniques. Over the next 50 years, manufacturing techniques advanced further, and today carbon fiber has become ubiquitous in high-performance products from race cars to airplanes. Now, with the advances in composites and the convenience of 3D printing, carbon fiber is more accessible to more people and for more applications, than ever before.

Making carbon fiber accessible through 3D printing

Traditional carbon fiber vs. composite blends

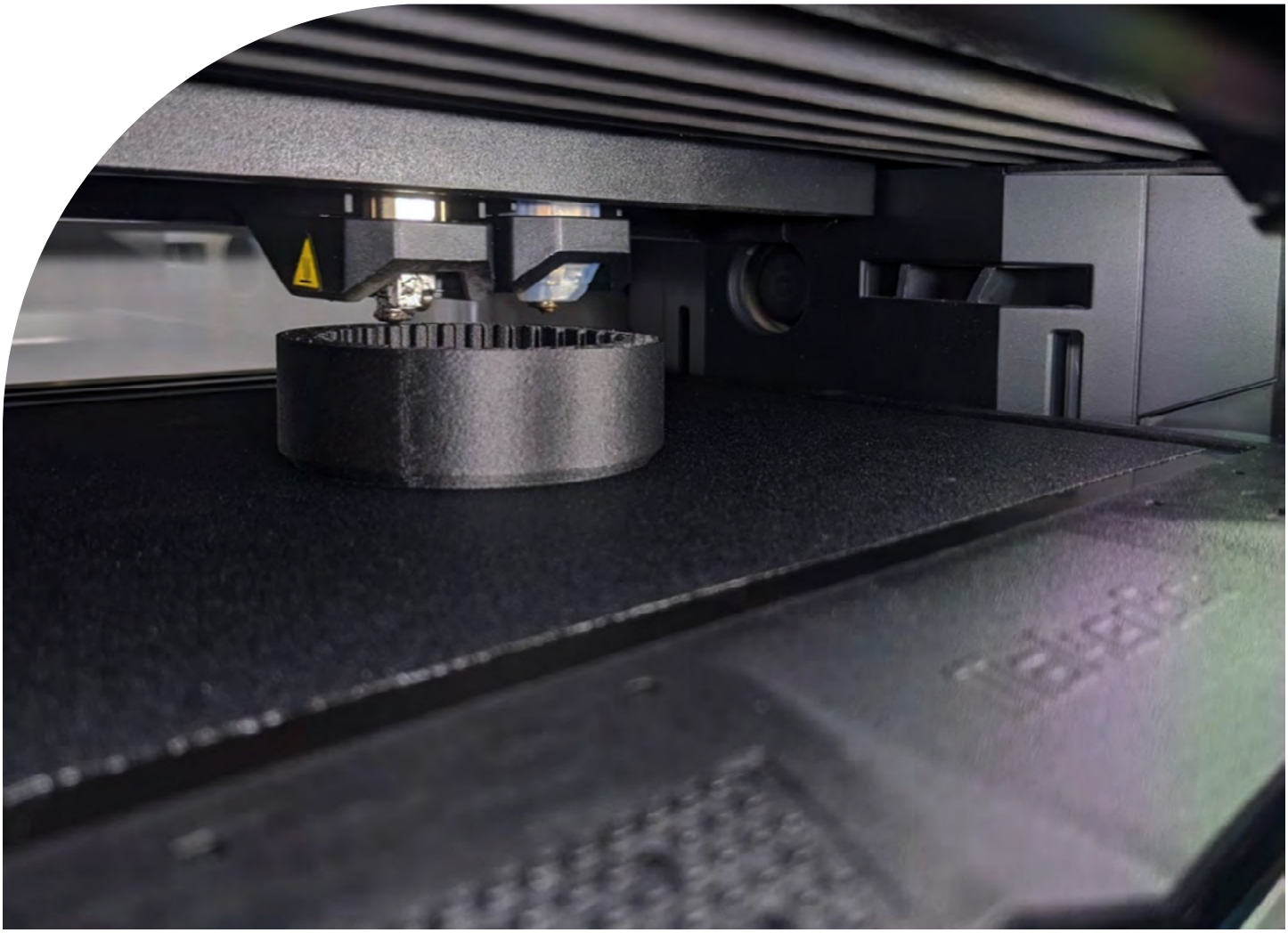
When you think of carbon fiber, the first thing that likely comes to mind is some type of exotic race car, sporting goods, or aircraft part - easily identified by the graphite black cross-weave pattern that is both incredibly strong and lightweight. Creating parts using the carbon fiber layup or weave process produces incredible results, but can also be labor-intensive and cost prohibitive due to the many steps required to produce a part.

Enter carbon fiber composite blends. In composite blends, carbon fiber goes through the process of chopping and mixing with a base resin or polymer. The result is a material that is easier to work with (you can use techniques like injection molding, machining, and 3D printing). Another added benefit of compositing carbon fiber is the ability to introduce additional properties through the use of a variety of base polymers (nylon, for example, can add a level of impact strength to reduce the brittleness of carbon fiber).

Composites manufacturing techniques

While composites already bring a certain accessibility to carbon fiber by opening up the material to mass production techniques, 3D printing enables the use of carbon fiber for low-volume and low-effort parts. With 3D printing, you can easily make a single tool that will be used for one specific application by one user. You can also go through an iterative process by which that tool continues to be improved upon as new insights or requests come in. Thus, a part such as a fixture or jig that would seem crazy to produce out of carbon fiber using traditional methods, becomes entirely plausible and often the most logical choice for when using 3D printing.

To understand why, you need to understand the basic benefits of 3D printing over other manufacturing processes. With an FDM 3D printer, you just need a spool of material and a 3D design file. Start the print, and in a few hours, you'll have the completed part. By contrast, an injection molding process requires the design and manufacture of the mold ahead of time. Similarly in machining, the setup requires fixtures to be set up, a CAM program to be created, and possibly multiple manipulations of the part by an operator throughout the machining process. In a nutshell, 3D printing requires very little setup or monitoring during the manufacturing process making it a fairly simple, automated process.



Identifying opportunities

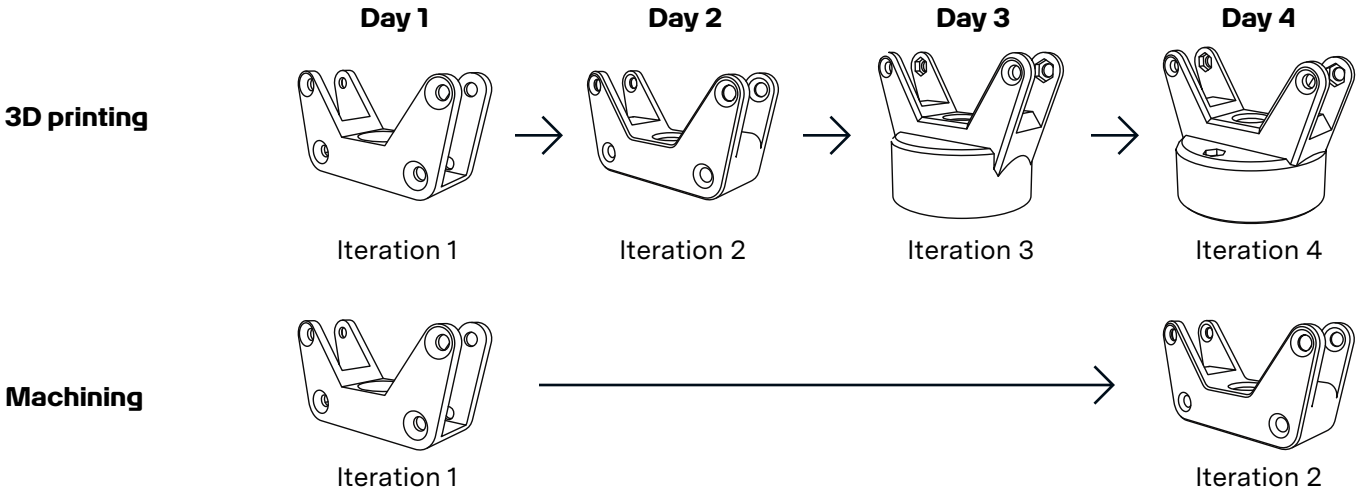
When does 3D printing make sense?

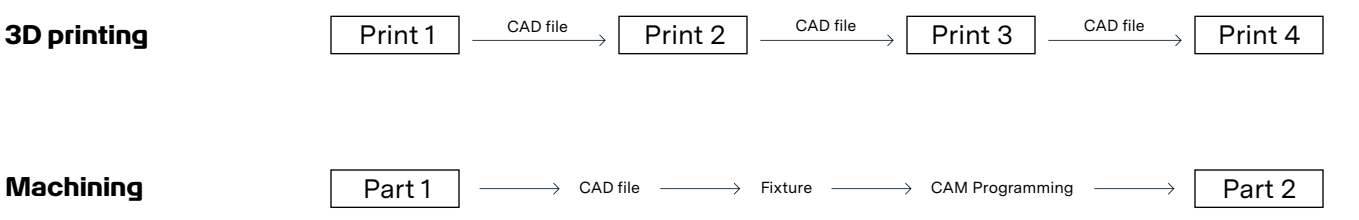
Before you dive in, buy a 3D printer, and start replacing all of your parts and processes, it is important to understand where 3D printing carbon fiber composites makes sense. Just like any technology, there are pros and cons to 3D printing, and if you are going to use it for a business application, you want to ensure there is a real return on your investment.

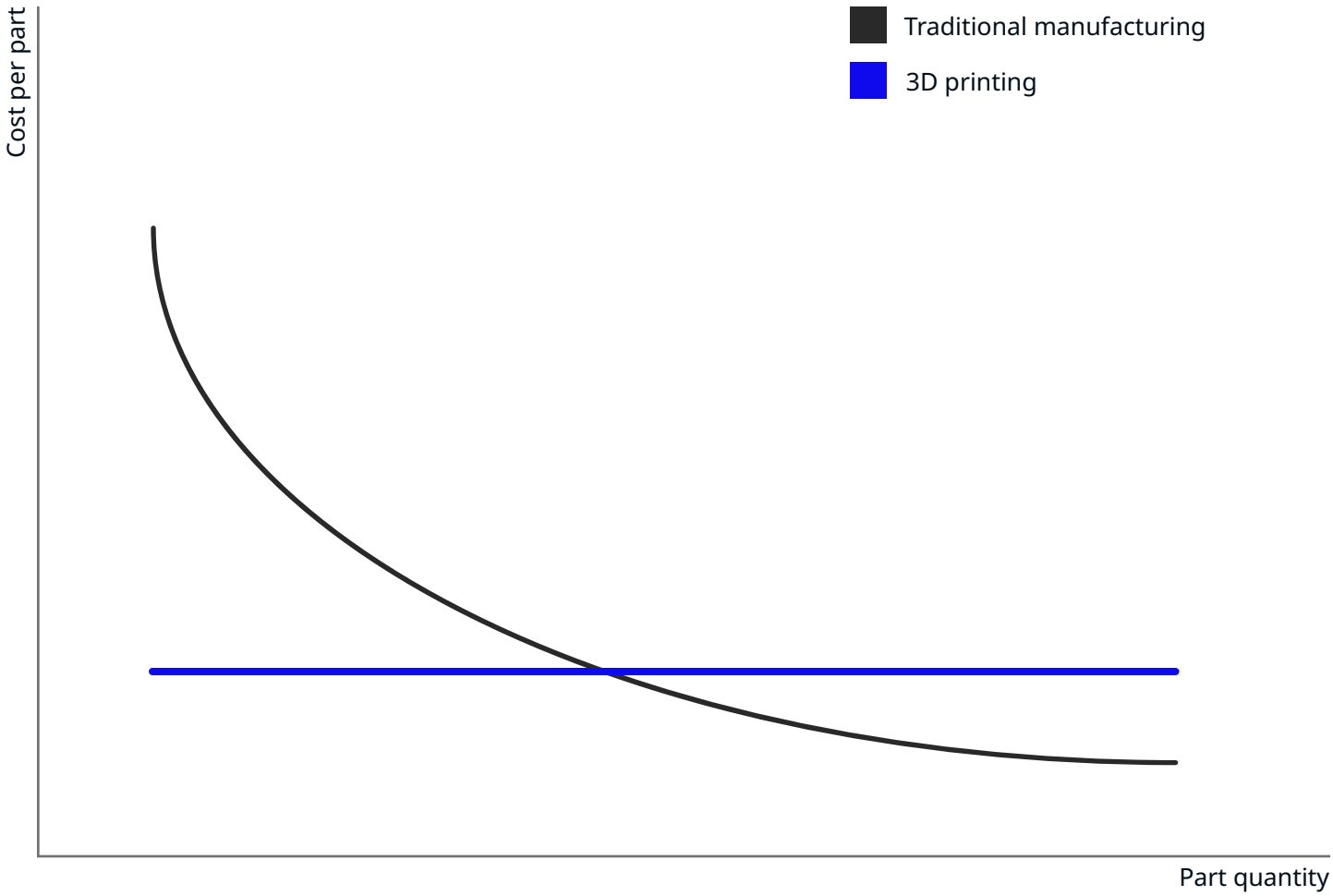
Save time with design iterations

A major benefit of 3D printing, as mentioned above, is the ease of setup compared to both injection molding and machining which can result in a huge time advantage. Going directly from design to starting a print job, without the extra setup, means that individual parts require significantly less labor to create.

That time advantage is further multiplied if you continue development on the part to improve it through multiple iterations.







Cost per part based on volume

When creating a high volume of parts, the extra setup that is required by injection molding and machining makes more sense. The time you spend setting up will pay off when you use the machine fixtures or injection molding to mass-produce large quantities of parts. Thus, you should always look at the volume of parts that you require.

If large volumes are your goal, then more traditional means of production are likely going to make more sense. However, if low volume is your goal - as may be the case with prototypes, custom/highly specialized tools, or replacement parts - 3D printing is almost always going to make the most sense from a cost standpoint.

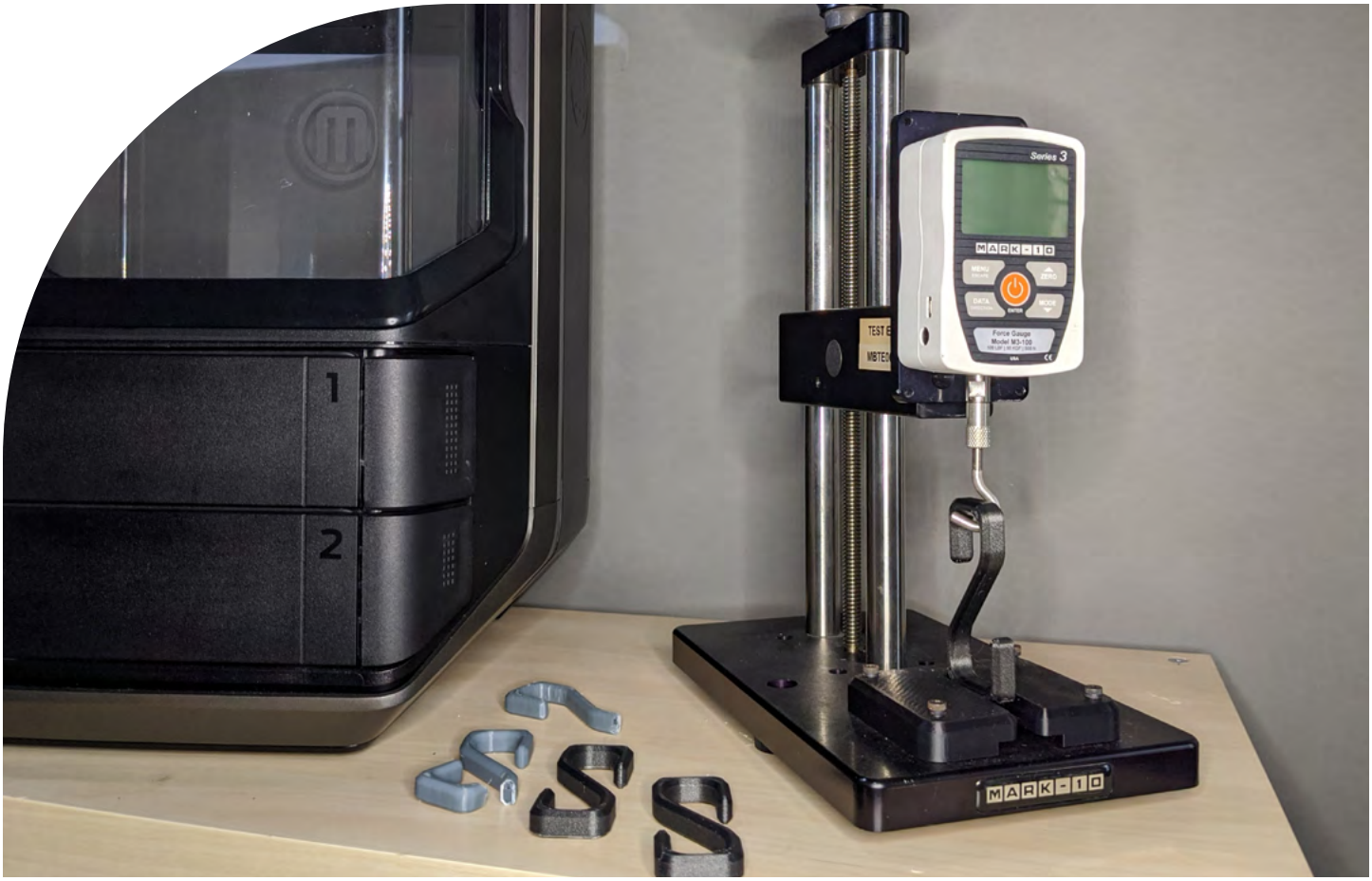
Material property requirements

When considering material and manufacturing processes, you will also need to understand the properties required for your specific application. What stresses and strains will the part undergo? What type of temperature thresholds will the part need to withstand? Will the part be exposed to moisture or chemicals?

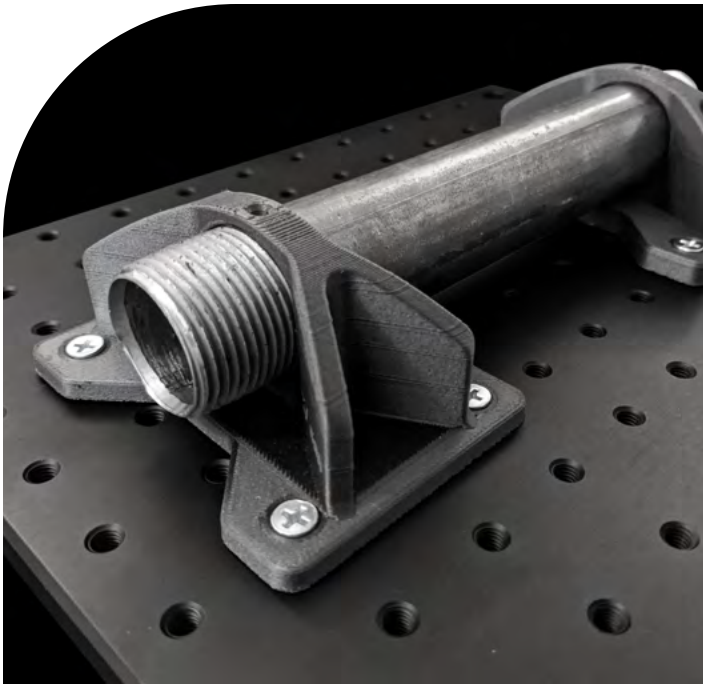
Certain parts may require the structural strength of steel. But just because a part is currently made out of metal does not mean it **needs** to be made out of metal. In fact, many parts are made out of metal simply because metal is a common and reliable material for high-performance parts. In reality, carbon fiber composites can often meet or exceed the requirements of these parts.

Understanding the following property requirements of your part can make your exploration of 3D printing much easier to fully comprehend.

- Load
- Stiffness
- Durability
- Heat deflection
- Special properties
  - ESD: resistance to electrostatic discharge
  - Flame retardancy
  - Chemical resistance
  - Electrical conductivity



Example carbon fiber 3D printing applications



Welding fixture

Welding often requires custom fixtures that hold the pieces together in advance of the welding process. These fixtures can be easily designed in CAD and 3D printed to minimize labor time while ensuring a tight tolerance fit. Nylon 6/66 carbon fiber is an ideal choice for this application thanks to its high heat deflection temperature and rigidity.

Bending die

Bending dies are used in conjunction with a hydraulic press to shape and form metal parts. Depending on the job or facility, these parts may benefit from 3D printing for quick customization from one job to the next. Carbon fiber composites are a great material option thanks to their rigidity - allowing the part to hold its form under more pressure than many other polymers.

End-of-arm tooling

When it comes to manufacturing automation, robotic arms are becoming ubiquitous as a tool for streamlining mundane tasks with unparalleled precision. End effector tools can come in all shapes and sizes, so the ability to 3D print these makes the possible applications nearly endless. The payload of the robotic arm is limited so reducing the weight of the tool through 3D printing with a carbon fiber composite can help quite a bit. This leaves the robot arm with the ability for increased payload, speed, and/or maneuverability.

Alignment tool

Alignment tools or gauges are used for quickly measuring during the manufacturing or assembly process. The rigidity of carbon fiber composite makes it a perfect material as it ensures the part won't flex or compress during measurement which could result in incorrect tolerances and inconsistent assemblies.

UltiMaker carbon fiber composites

PET CF

PET Carbon Fiber has high strength, stiffness, and temperature resistance, which can all be enhanced through annealing. The annealing process will improve the temperature resistance of your parts from 80 °C to a phenomenal 181 °C, while also increasing their strength by 30% and stiffness by 10%.

PET CF also has low moisture sensitivity and high reliability, making it significantly easier to print than other composites.

- Filament diameter: 2.85 mm
- Print Core: CC
- Support: PVA

Clutch inlet
Print time: 19h 46m

Switch bracket
Print time: 5h 33m

ABS Carbon Fiber

This material combines the reliability of ABS on the Method series with the performance of carbon fiber. ABS Carbon Fiber is also the only composite on the Method series that is compatible with the RapidRinse support material, opening up limitless design flexibility with easy and convenient support removal.

Filament diameter: 1.75 mm
Extruder: 1C
Support: RapidRinse

Cycling computer mount
Print time: 1h 17m

Textured mechanical gripper
Print time: 19h 50m

Nylon carbon fiber (Nylon 6/66 blend)

Nylon 6 carbon fiber has the strength and lightweight benefits of other carbon fiber composites. The main thing about nylon 6 that sets it apart from others in that category is its ability to withstand higher temperatures. The heat deflection temperature is significantly higher than many of the popular base polymers. In the case of MakerBot Nylon Carbon Fiber, the HDT is 100°C higher than that of ABS and 93°C higher than regular nylon 6.

Filament diameter: 1.75 mm
Extruder: 1C
Support: SR-30

Pipe fitting bracket
Print time: 4h 44m

Positioning fixture
Print time: 7 h 51m

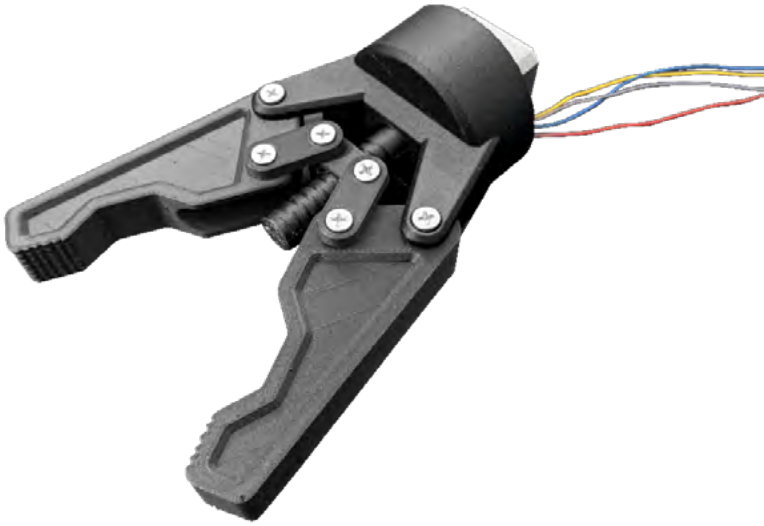
Nylon 12 carbon fiber

Much like nylon 6 carbon fiber, the nylon 12 variant has the benefits of strength, stiffness, and lightweight. Unlike nylon 6, nylon 12 has a better resistance to moisture uptake, making it somewhat easier to print and giving the printed part a cleaner final appearance without the need for post-processing.

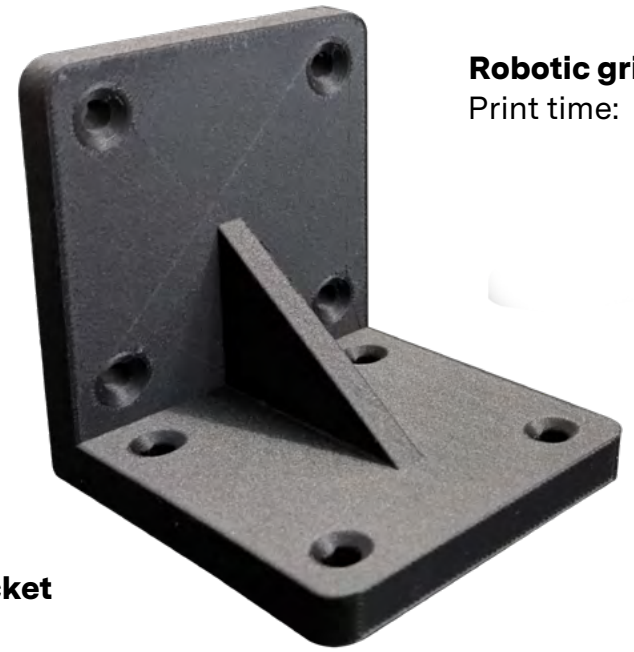
One drawback of nylon 12 compared to nylon 6 is that it will generally have a lower HDT - so you really just need to weigh what is most important for your specific application.

Filament diameter: 1.75 mm
Extruder: 1C
Support: SR-30

Pipe welding fixture
Print time: 8h 40m



Robotic gripper assembly
Print time: 17h 23m

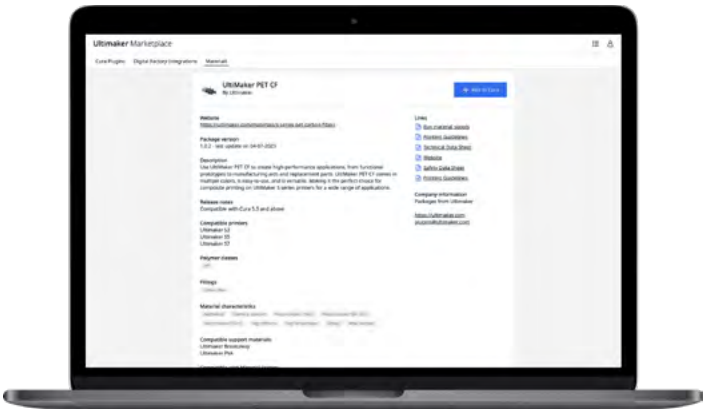


Rectangular bracket
Print time: 5h 7m

Third-party materials

Both the S series and Method series of UltiMaker printers have access to a wide range of third-party materials, including carbon fiber composites.

S series



Over 300 third-party material profiles for S series printers on the UltiMaker Marketplace.

- Avoid manual setup for third-party materials
- Download material profiles from leading brands for your application
- Download useful plugins to customize the print preparation experience, star-rated by our community

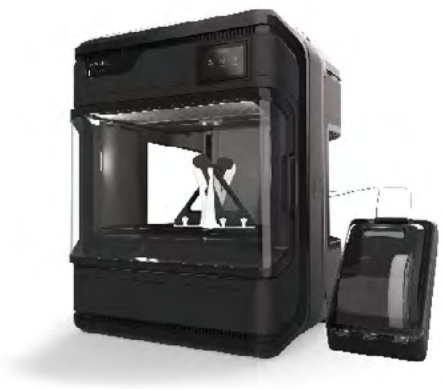
Method series

Unlock third-party materials on your Method series printer with the Labs Extruder

- Slot the Labs modular extruder into your Method series printer to unlock additional capabilities
- Access advanced print settings to maximize the quality of your prints
- Print with compatible composites from leading brands such as Kimya and Jabil

UltiMaker printers

The UltiMaker portfolio offers two great printer lines for professionals who want to print composites.



	Method series	S series
Filament diameter	1.75 mm	2.85 mm
Third-party composites	✓	✓
Soluble supports	✓	✓
Cloud printer management	✓	✓
Air Manager*	✓	✓
Flexible build plate	✓	✓
Heated build plate*	✓	✓
Heated chamber	✓	

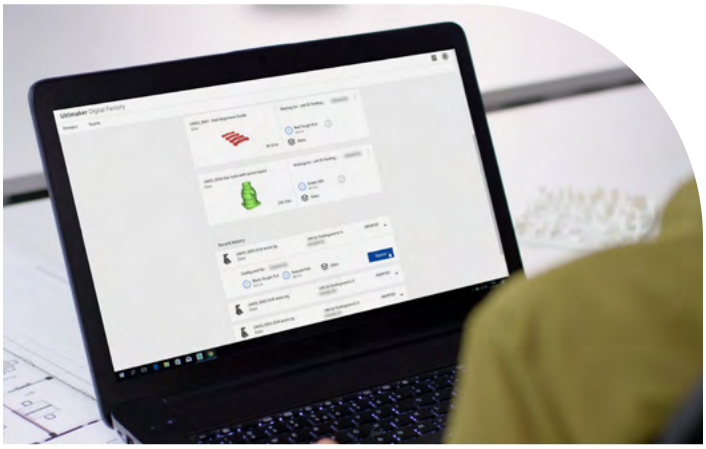
*Not available for all printer models and may require additional purchase.

S series: Composite printing flexibility

Unique features

Printer management with UltiMaker Digital Factory

Connect your S series printer to Digital Factory to effortlessly upgrade your 3D printing experience. Via a set of cloud-based tools, you can manage your printers and your print files with ease. Including an UltiMaker Cura integration for a seamless workflow.

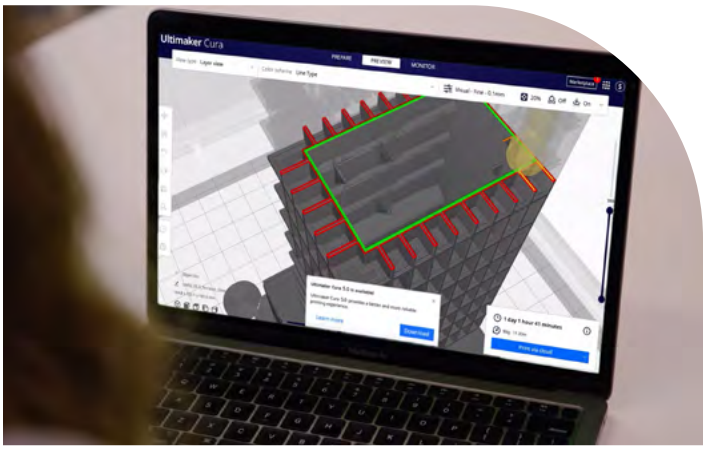


Access to over 300 materials with the UltiMaker Marketplace

Alongside the materials UltiMaker offers, you also have access to the largest selection of third-party material profiles in the industry with the UltiMaker Marketplace. Including a wide range of different carbon fiber composite options for true freedom and flexibility in your composite printing.

Exclusive UltiMaker Cura features

By using an UltiMaker S series printer, you gain access to exclusive print profiles and features that will speed up your workflow and increase your print success - like intent profiles, easy remote printing, and more.

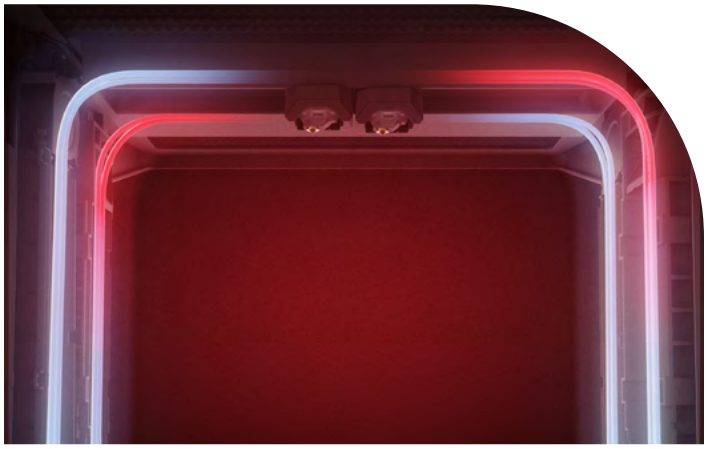


Method series: Carbon fiber in a heated chamber

Unique features

Circulating Heated Chamber

The Method series uses our patented Circulating Heated Chamber to rapidly warm the entire build chamber up to 110 °C, providing optimal print conditions from the first layer to the last. The result is a degree of dimensional accuracy typically reserved for high-end industrial 3D printers



Modular extruder platform

The 1C Composite Extruder for the Method series conveniently comes included with the Method X Carbon Fiber Edition. This extruder has been optimized with hardened parts to print abrasive composites longer. With the modular extruder platform, you can switch between different extruders in seconds without the need for tools, giving you the flexibility to jump between material groups and applications.

UltiMaker CloudPrint slicing and monitoring

Included with all Method series 3D printers is the ability to use CloudPrint - our cloud-based 3D printing and collaboration tool. With CloudPrint, you can access your Method 3D printers remotely from anywhere in order to set up workspaces and to give your teammates access to use your printers. Unleash the full power of the Method series with CloudPrint.

Reliable 3D printers that simply work for you

Discover the UltiMaker 3D printers that will streamline your workflow and deliver the quality results you need.

What does our unique platform include?

- Workhorse 3D printers that achieve fast ROI
- Access to third-party materials
- Secure cloud software for easy remote printing
- Global access to expert support and learning

Learn more at ultimaker.com