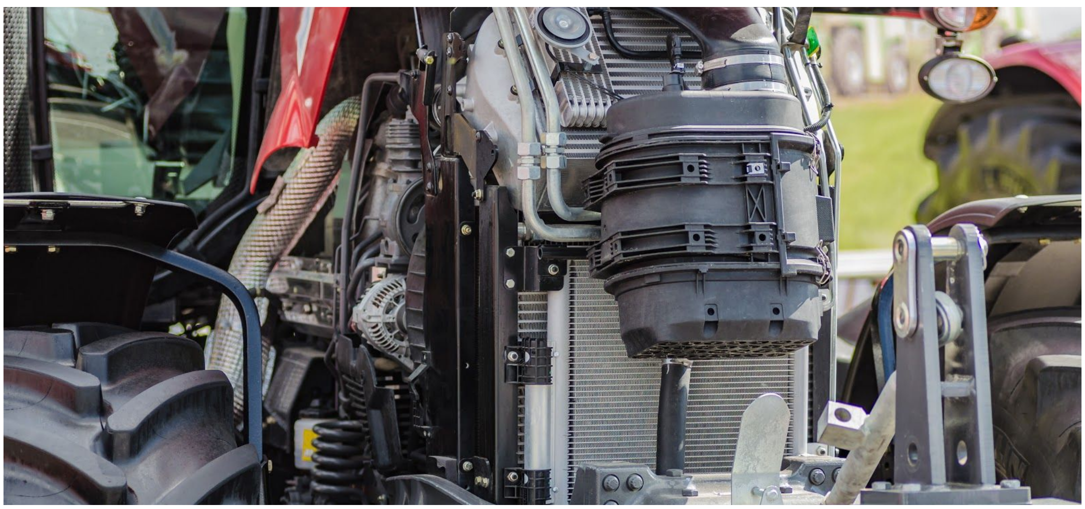
RapidMade, Inc.
15883 SW 72nd Ave.
Portland, OR 97224
503-943-2781 | info@rapidmade.com

Post-Printing Carbon Fiber Reinforcement — 3D Printed Parts for Industrial Farming

A RapidMade White Paper

By Rae Eaton

Advances in farming technology often put small-scale farms at a disadvantage due to the economies of scale involved. Because most farmed products in the United States are sold close to cost, capital investments in equipment can significantly decrease profitability, both through expenses and time lost to replacement and repairs. Moreover, as manufacturers discontinue support for older farming equipment in favor of newer models, repairing or replacing discontinued parts can become prohibitively expensive. 3D printing's ability to reverse engineer part designs from equipment scans and make individual components as needed offers a viable alternative to traditional machining that can lower the cost of equipment repairs, especially when paired with new material technologies like carbon fiber reinforcement.



Modern agricultural equipment uses many specialized parts that can be expensive to replace, especially if they have been discontinued.

3D printing technologies are already known for their inexpensive and fast prototyping capabilities in agriculture, and applications for end-use products are on the rise. In the last decade, the percentage of end-use 3D printed products has grown by 25%. As carbon fiber and metal printing have become more available, 3D printing of industrial end-use parts is emerging as a feasible alternative to traditionally machined components. However, the current methods of printing with these materials can require more expensive materials, equipment, or both.

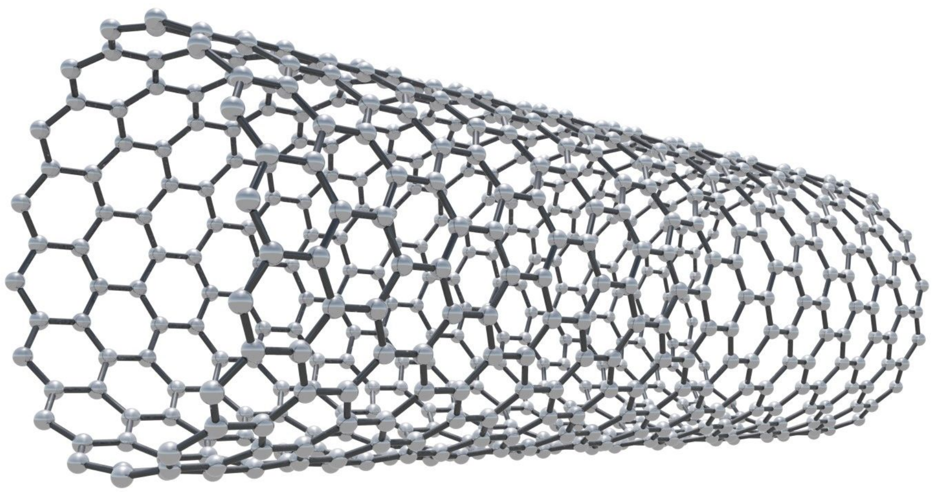
RapidMade is developing a low-cost technique to strengthen 3D printed pieces by externally applying with carbon fibers to plastic prints. This creates a less expensive 3D printing solution with a wider range of general applications. By deploying this new technology in rural manufacturing centers, RapidMade hopes to bring the benefits of additive manufacturing not only to small- and mid-sized farms but to entire rural communities.

RapidMade, Inc.
15883 SW 72nd Ave.
Portland, OR 97224
503-943-2781 | info@rapidmade.com

The Current Field of Industrial Additive Manufacturing

Additive manufacturing is already used to create durable metal replacement parts for machines. But while metal-based 3D printing may seem like an intuitive choice, professional metal printers cost up to 25 times more than most professional plastic printers, making it the most expensive class of 3D printer.[1]

Carbon fiber-reinforced prints offer a promising alternative to metal printed parts. Carbon fibers are composed of carbon-based crystals that align in long, parallel strands. Individually, these fibers are strong but brittle. When incorporated into other materials such as 3D printed plastics, however, they can more than double the strength and flexibility of a plastic part without increasing its weight.



Carbon crystals create tubes that align in parallel strands to form carbon fibers.

Current methods for incorporating carbon fibers into plastic printed parts occur during the 3D printing process using fused filament fabrication or continuous filament fabrication. For fused filament fabrication, a filament is used which contains a mixture of short carbon fibers and plastic. Continuous filament fabrication, on the other hand, involves a secondary nozzle which patterns carbon fiber strands into the plastic piece throughout the printing process, which provides the added benefit of being able to use carbon fiber to selectively reinforce load-bearing areas.

Carbon fiber parts printed with continuous filament fabrication are 30 times stronger than Nylon 12 parts and have tensile strength that is almost equivalent to metal printed parts, while those printed with fused filament fabrication are significantly less expensive than continuous filament fabrication parts but are only about twice as strong as Nylon 12 parts.[2]

Although these carbon fiber printing methods are capable of increasing the strength and durability of pieces, there are cost and manufacturing considerations which limit their viability in many cases. In particular, carbon fiber printing requires specialized printer equipment and has a higher failure rate than

[1] Prices based on a comparison of market values for professional metal and Nylon 12 3D printers.
[2] The values used for these comparisons were taken from Materials Data Sheets produced by Stratasys Direct, Inc. and Markforged, Inc. for chopped carbon fiber Nylon 12, continuous carbon fiber, and AlSi printed material.

RapidMade, Inc.
15883 SW 72nd Ave.
Portland, OR 97224
503-943-2781 | info@rapidmade.com

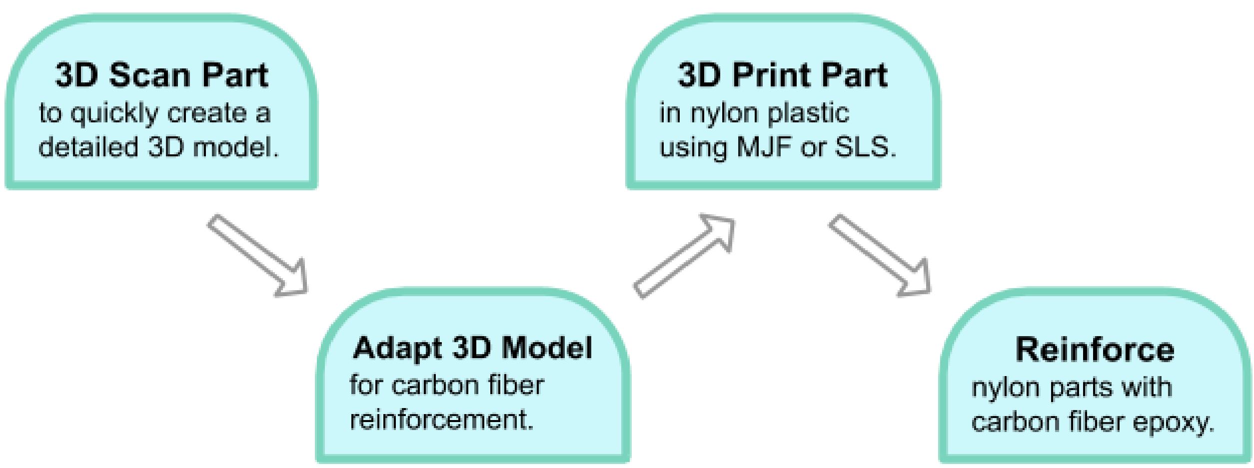
other 3D printing methods. This equipment can be very expensive, and part failures further increase costs per part. Taken together, these considerations greatly reduce the usefulness of carbon fiber-infused plastics for resource-limited rural communities.

The Working Solution

In partnership with Oregon State University, RapidMade is developing a method to create custom parts using a hybrid 3D printed core that is reinforced with a carbon fiber epoxy surface. Much like continuous filament fabrication, carbon fiber epoxies can be selectively applied to plastic printed parts to reinforce load-bearing portions. Instead of incorporating carbon fibers into the printing process, however, this new technology uses selective laser sintering or Multi Jet Fusion printing to create a nylon plastic part according to customer specifications. Carbon fiber epoxy is then chemically bonded to the surface to provide reinforcement as needed. In the initial stages, RapidMade is working to characterize the strength and reliability of this nylon-carbon fiber bond to ensure that it meets the mechanical properties required of industrial equipment.

As part of this project, RapidMade and OSU are also creating design software that will allow users to optimize their designs for use with this carbon fiber technology. To accomplish this, they will be evaluating part designs with a specific focus on where to apply carbon fiber reinforcement to maximize component strength and flexibility while minimizing weight and material costs. The team plans to use their findings to create an application that will allow users to easily incorporate carbon fiber reinforcement into 3D printed replacement parts.

Using already existing technology, users can scan existing parts with a high-resolution 3D scanner to create a 3D model, which can then be used to quickly create 3D printed replacement parts, eliminating many of the issues associated with repairing obsolete machinery. This new software will incorporate RapidMade's research into the designs of replacement parts to optimize these 3D models for carbon fiber reinforcement.



Carbon fiber-reinforced nylon replacement parts can be produced in a four-step process.

These software design tools can be shared with local manufacturing hubs in rural communities or with individual farms equipped with 3D printers to bring the same level of performance to their additive manufacturing. Developing software that adjusts designs and suggests locations for carbon fiber reinforcement will lower the design barrier for custom parts and enable rural communities to be as self-sufficient as possible.

With Additive Manufacturing, Everyone Can Win

To bring this new technology to market, RapidMade and Oregon State University will work with local communities to develop manufacturing centers capable of producing on-demand custom parts for farms in the area. These centers will include all the necessary technology to recreate industrial parts, including a 3D scanner, selective laser sintering or Multi Jet Fusion 3D printer, carbon fiber-nylon curing oven, and other post-manufacturing equipment for sanding and finishing.

The flexibility and relatively low costs of additive manufacturing equipment make the creation of small-scale additive manufacturing hubs feasible. Enabling additive manufacturing in rural communities provides more than just cost-saving measures to local farms: these manufacturing centers will bring new economic opportunities to the communities of origin as well as provide the chance for on-site training and education in the community.

As additive manufacturing technologies continue to innovate, the price of producing end-use products in all industries will further decline. Additive manufacturing provides an opportunity to strengthen not only the economic outlook of all small- and mid-sized businesses but also the communities in which they reside. By empowering these communities to embrace carbon fiber-reinforced prints and other plastic manufacturing, RapidMade and OSU will enable businesses to ride this latest innovation wave rather than being swept away by it.