

A photograph of a golf club head, likely a sand wedge, lying on a green grassy field. The club head features a distinctive lattice-like or honeycomb structure on its face and sole. A golf ball is positioned to the right of the club head. The background is a lush green lawn.

Desktop Metal™

[E-BOOK]

Functional Prototyping using Metal 3D Printing

www.desktopmetal.com



Introduction

Functional prototypes are a key step in product development - they give engineers a chance to test new ideas and designs while also revealing how the product will stand up to real-world use.

And when it comes to functional prototypes, 3D printing is rewriting the rules of what's possible.

One of the most important changes made possible with printing relates to speed. Where it may take weeks or months for traditional manufacturing processes like casting and forging, 3D printers can turn out parts in just days.

For manufacturers, that translates into the ability to create not just one or two prototypes of a particular part, but many. By creating multiple prototypes with subtly different geometries, it's possible to test them simultaneously and quickly refine the design.

Printed parts can also be far more complex than their traditional counterparts, allowing designers to precisely tailor features and geometry to maximize part performance. That complexity enables the use of generative design tools to create highly-optimized, organically-inspired geometries that would be difficult - or nearly impossible - to manufacture with traditional methods.

With less material waste and no need for a dedicated, skilled operator, printing prototypes can be less expensive than traditional manufacturing.



Why doesn't everyone print prototypes?

Despite the potential benefits that come with 3D printing, the technology still isn't widely used for functional prototyping.

And much of the reason why has to do with how earlier-generation printers worked.

Though initially touted as a technology that would allow you to print virtually anything you need at home, parts created on early plastic printers were often plagued by poor resolution, high porosity and other defects.

While modern plastic printers can produce high-quality parts, many are still limited to producing visual prototypes, because plastic parts simply can't stand up to the loading conditions some parts face.

Without access to affordable metal 3D printing, engineers for the past two decades had no choice but to fall back on traditional processes - like milling, grinding, casting or CNC machining - to produce functional prototypes.

Those processes, however, are expensive, time-consuming and require skilled operators - all of which act as constraints on the creation of prototypes and the efficiency of the product development cycle.

These days, though, that picture is changing.

02 The Power of Metal 3D Printing

Those changes began when the first metal 3D printers - which used lasers to melt thin layers of metal powder - came on the market.

But because they were both slow and expensive - \$1 million or more for the systems and dedicated facilities - those systems were best suited to applications where low production and high per-part costs could be justified, like the aerospace and medical industries.

For other applications, where per-part costs must be lower or production faster, laser-based systems simply weren't cost effective.

With the development of the Studio System™, though, Desktop Metal is addressing those issues and more - making it both easier and more economical to create functional prototypes.



Desktop Metal™ Studio System™

Desktop Metal BMD™ Rods



The key technology behind the Studio System™ is Bound Metal Deposition™ - an FFF-style print process that heats and extrudes a rod media made of metal powder and a polymer binder, similar to the media used in metal injection molding (MIM).

Combining the ease of FFF printing with the well-established metallurgy of MIM, the system is able to quickly deliver high quality metal parts with reliable metallurgy - making it ideal for functional prototyping. In just days, users can print parts that would otherwise take weeks or even months using traditional manufacturing processes, enabling faster transitions from design to production.

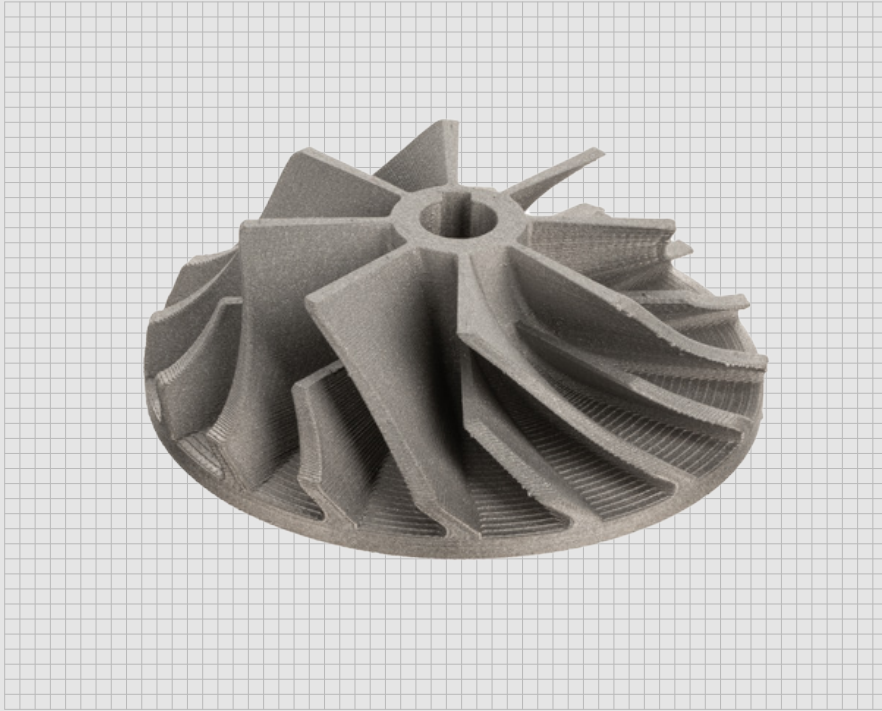
The Studio System™'s office-friendly design eliminates the use of loose powders and dangerous lasers, making it an easy-to-use, end-to-end solution for printing metal parts in-house.

The system is also capable of printing using a variety of metals - including H13 tool steel, 4140 chromoly steel, 316L stainless steel and 17-4 PH stainless steel - allowing companies to create functional prototypes in the same materials they will later use for mass production.

3D Printing vs. Traditional Manufacturing

[Part Example]

Chemical Impellers



[Industry]

Oil & Gas, Chemical, Industrial

[Cost Saving]

93%

Studio System™

\$70

CNC

\$1,000

[Time Saving]

79%

Studio System™

3 Days

CNC

2 Weeks

[Key Benefits with Studio System™]

- Reduced prototyping cost
- Many design variants

[Description]

Commonly used across a variety of industries, impellers are an essential component in pumps used to move fluid through systems. For chemical impellers, stainless steel 316L is ideal due to its chemical resistance and mechanical properties at extreme temperatures, such as those found in cryogenic, salt water, and petroleum pumps.

Impellers require complex vanes to optimize the pressure profiles in the pump. The optimum geometry of each impeller depends on the viscosity of the fluid and the specific requirements of each application.

Functional prototypes of new impeller designs would traditionally be made via CNC machining or investment casting, and would cost as much as \$5,000 or more due to their complex geometry.

With the Studio System™, the same prototype can be printed for just \$70. By significantly reducing the cost, designers are able to test multiple variations of the same part before selecting the optimum geometry for production, achieving the best possible result.

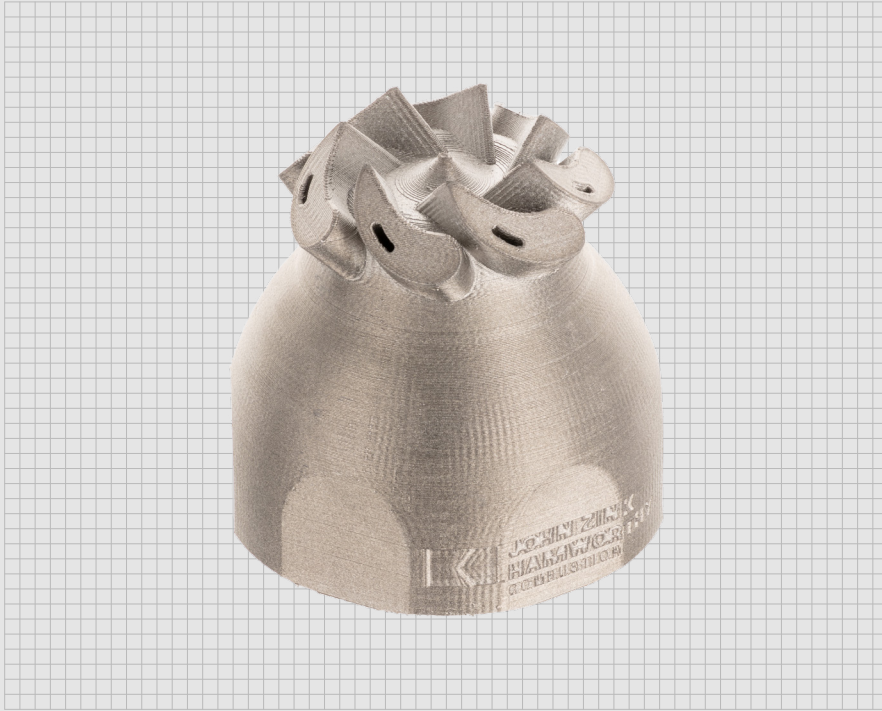
3D Printing vs. Traditional Manufacturing

[Part Example]

Fuel Atomizer

[Industry]

Energy, Naval, Industrial



[Cost Saving]

88%

Studio System™

\$129

DMLS

\$1,089

[Key Benefits with Studio System™]

- Can only be manufactured using 3D printing
- Reduced prototyping cost

[Description]

John Zink Hamworthy Combustion is a global authority on emissions control and a pioneer in modern Smart Combustion™ solutions. Early on, JZHC recognized the potential that additive manufacturing could have in their industry, and decided to radically redesign their fuel atomizer used in steam propulsion boilers to function in a more fuel-efficient manner.

The Studio System™ allowed JZHC to create functional prototypes at far lower cost and in far less time - days rather than weeks - than traditional methods. Stainless steel 316L was chosen for its excellent mechanical properties at high temperatures, and corrosion resistance in marine environments.

Today, the same nozzles used for prototyping are used while LNG tankers are maneuvering in port, realizing an improved fuel efficiency of almost 100% and significantly reducing the operational costs and environmental impact of the systems.

3D Printing vs. Traditional Manufacturing

[Part Example]

Golf Clubs

[Industry]

Sporting Goods

[Cost Saving]

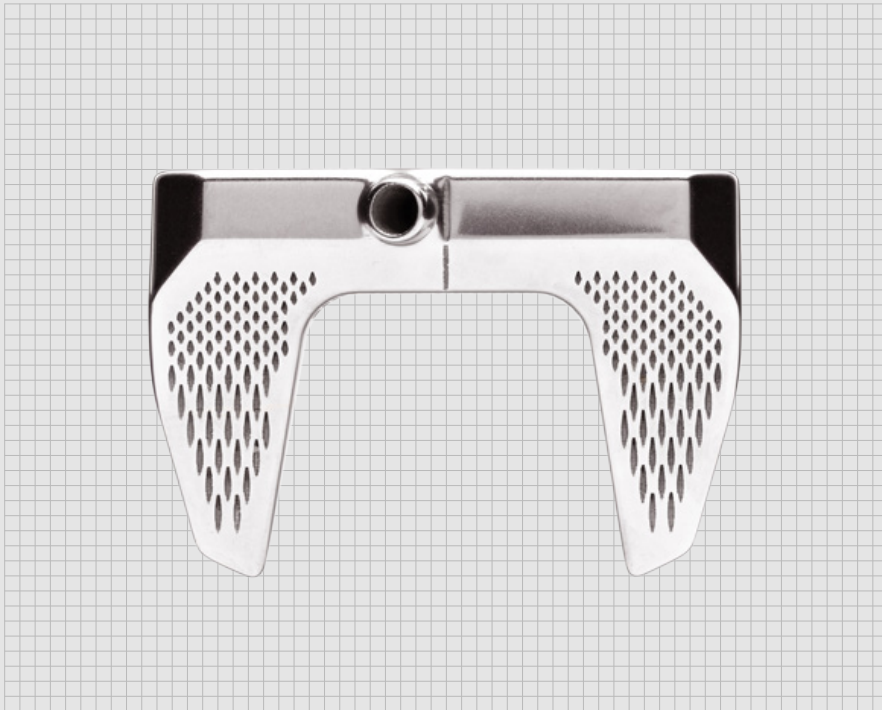
94%

Studio System™

\$128

CNC

\$2,203



[Key Benefits with Studio System™]

- Many design variants
- Shorter lead times

[Description]

Golf club designers must consider any number of parameters - from the angle of the club base to the shape of the cavity and the weight of the club to name just a few. In addition to club features, designers consider the anatomy and preferences of each player. To explore that vast design space, testing with functional prototypes is crucial.

Traditionally, creating those prototypes starts with a blank - basically a rough club shape - which is then machined to create different features. But because each prototype starts from the same basic blank, the options for different designs are limited.

With additive manufacturing, it's possible to access entirely new design options - for example, by altering the infill percentage in a club to fine-tune its weight distribution. The technology also opens the door to mass customization and the use of generative design tools to optimize clubs for individual golfers.

While golf clubs are typically made via casting or forging, both processes are prohibitively expensive for prototyping due to high start-up costs. Using the Studio System™, designers can create and test a number of design variants, ultimately leading to better club design and quicker time to market.

3D Printing vs. Traditional Manufacturing

[Part Example]

Shock Absorber Piston Valve



[Industry]

Automotive, Transportation

[Cost Saving]

83%

Studio System™

\$41

CNC

\$245

[Key Benefits with Studio System™]

- Many design variants
- Need for Additive Manufacturing

[Description]

Shock absorbers are essentially hydraulic oil pumps. In the heart of every shock absorber lies a piston valve which directs the flow of oil during the compression and extension of the suspension system. The geometry of the valve is one of the main parameters that determine the response of the shock absorber under various conditions, so optimizing its design is critical.

Piston valves are traditionally manufactured via press and sinter, resulting in a number of design constraints, including on the orientation of the channels that control the flow of oil through the piston.

The Studio System™ allows engineers to fabricate a number of variations on the valve in a matter of days, expediting the design process, and enables the exploration of new geometries, like internal channels, that can only be manufactured using additive technologies.

3D Printing vs. Traditional Manufacturing

[Part Example]

Engine Piston Head



[Industry]

Automotive

[Cost Saving]

52%

Studio System™

\$271

CNC

\$568

[Key Benefits with Studio System™]

- Shorter lead times
- Need for Additive Manufacturing

[Description]

A key component of every internal combustion engine, pistons compress the air and fuel mixture that is ignited by a spark plug, turning the crankshaft and driving the engine. From a design perspective, pistons must be both lightweight to minimize the extreme forces it experiences, yet still stiff enough to withstand the pressure generated during combustion.

To create functional prototypes of new piston designs, manufacturers typically rely on CNC machining, but the complex geometry of pistons often results in long lead times which slow the design process.

Using the Studio System™, engineers can produce functional prototypes for testing in a matter of days rather than weeks, allowing for quicker iteration before arriving at a final part. Using generative design tools, engineers can create pistons that optimize both stiffness and lightweight, but which are difficult, or even impossible, to manufacture with traditional methods.

About Desktop Metal

Desktop Metal, Inc. is accelerating the transformation of manufacturing with end-to-end 3D printing solutions.

Founded in 2015 by leaders in advanced manufacturing, metallurgy, and robotics, the company is addressing the unmet challenges of speed, cost, and quality to make metal 3D printing an essential tool for engineers and manufacturers around the world.

In 2017, the company was selected as one of the world's 30 most promising Technology Pioneers by the World Economic Forum, and was recently named to MIT Technology Review's list of 50 Smartest Companies. For more information, visit www.desktopmetal.com.

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