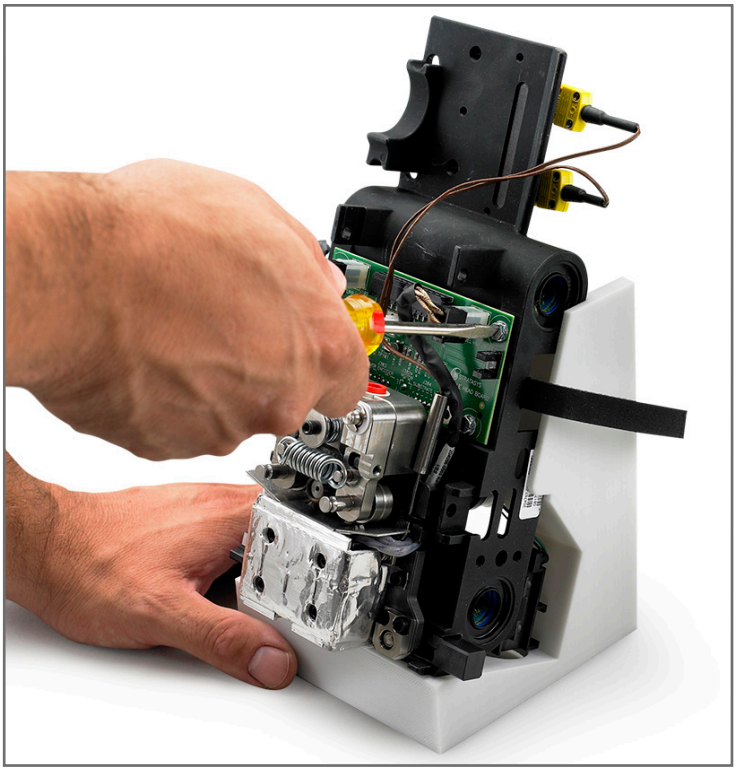
REVOLUTIONIZING MANUFACTURING WITH 3D PRINTING: AN INTRODUCTION

With traditional manufacturing methods, it's not practical to manufacture a single item or short run of products — it's simply too expensive, in terms of both time and money. Securing factory space, setting up a production line, creating a mold and procuring jigs and fixtures all incur substantial costs that can't be justified for a few items.

But what if there were a way to fill those needs for far less expense? And what if those items could be created overnight, in-house and in a hands-off process? That's exactly what 3D printing offers manufacturers: the freedom to test more ideas; to make exactly what's needed, whenever it's needed; to customize parts and tools for unique applications; and ultimately, to make better products.

Stratasys
FOR A 3D WORLD™

White Paper



With an in-house 3D printer, manufacturers can create tools such as assembly fixtures and jigs overnight and put them into use the next day.

3D printers and 3D production systems can help manufacturers create detailed prototypes, essential manufacturing tools and durable end-use parts — without sharing confidential design information or waiting weeks for items to be shipped.

PROTOTYPES: GETTING IT RIGHT FROM THE START

With an in-house 3D printer, manufacturers can inexpensively produce multiple iterations of a design. Today's 3D printers are capable of producing realistic, precise multi-material prototypes that incorporate everything from rubber grips to clear panels. Or, specialized materials with certifications for biocompatibility or temperature and chemical resistance, can take prototyping to a functional level. These accurate models give manufacturers the opportunity to identify problems and perfect the details of their designs before moving forward.

Catching design errors before committing to a production run can yield big savings, but there's another benefit to using 3D printing at this early stage: When prototype production is quick, inexpensive and readily accessible, designers make more prototypes to test their ideas thoroughly.

"It's important for our prototype parts to look and feel like production parts," said Mike Zeigle, manager of Trek's prototype development group. "The new Objet500 Connex3™ 3D Printer allows us to print multiple materials in multiple colors."

"A good example is, in the morning, we print handle bar grips on the Connex3, and we put them on the bike. Our test riders take the bike to the trails across the road for a test ride," added Zeigle. "By the end of the afternoon, the engineer either has a good design, or he can go start all over again, make some modifications to it and the next day make another part."

OUTSOURCED OR ON SITE?

Manufacturers with experience outsourcing 3D printed parts sometimes find it difficult to justify the cost of acquiring equipment on site. But often, once they have in-house 3D printing capabilities, they realize a broader set of applications that prove more than valuable enough to justify the investment. Fender Musical Instruments Corporation, known for its iconic guitars, has decreased its time to market by 40 percent by moving to in-house 3D printing.

The switch from using a service bureau meant that instead of waiting as long as two weeks for a prototype, Fender designers produced one overnight. In addition, Fender found that it was ultimately half as expensive to produce its own prototypes; it typically costs just $4 to $6 per cubic inch to produce a part on a 3D printer.

Trek's Objet500 Connex3 created this durable Digital ABS™ chain guard with rubber-like components in one print job.

But the question of where to have prototypes made doesn't have to be an either/or choice. Some customers own one or more 3D printers and opt to supplement their production by outsourcing to service bureaus offering production facilities around the globe. This is a perfect solution for when they need extra capacity or a larger build size than their own machine can accommodate.

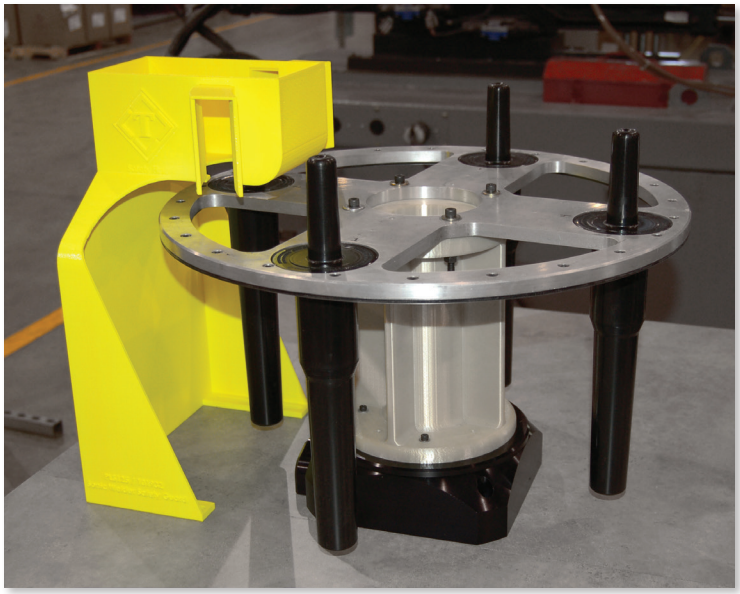
TOOLS: MAKING THE THINGS THAT MAKE THINGS

Many manufacturing tools can be created with 3D printing more quickly, and less expensively, than with traditional methods. Molds, templates, jigs and fixtures — all can be ready for use in hours, not weeks.

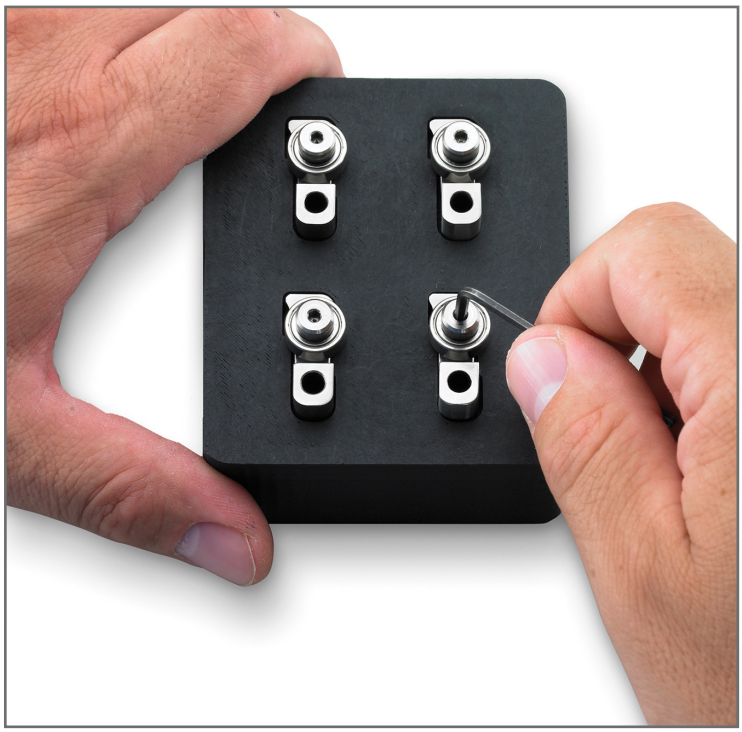
Thogus Products is an injection molder that specializes in low-volume manufacturing and highly engineered materials. According to Natalie Williams, quality manager at Thogus, "It is so much easier for me to model a fixture and print it myself than it is to design it and work through an outside machine shop."

A PATH TO SAVINGS — AND SPEED

"Jigs, fixtures, guides and gauges are usually produced in very low quantities, so they are expensive," said Terry Wohlers, 3D printing expert and president of the independent consulting firm Wohlers Associates. "3D printing is often better at producing low volumes compared to conventional manufacturing, so companies can reduce time and cost."



Thogus Products used 3D printing for part extraction and placement, reducing direct labor and expenses.

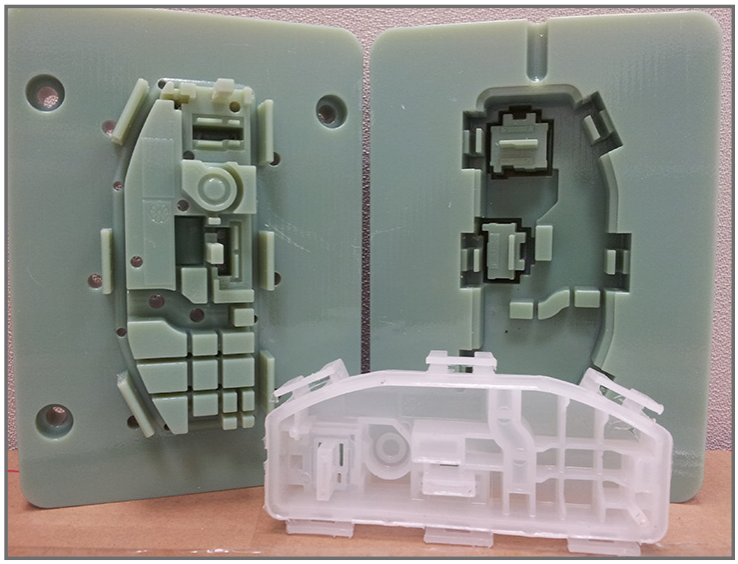


Tools such as assembly fixtures and jigs are ideal candidates for 3D printing, which can easily produce small numbers of custom-designed items.

For Thogus, 3D printing is easy and fast. "For one 12-cavity CMM fixture, the lead time, if outsourced, was 7 to 10 days. I built it overnight," said Williams. Manufacturers using FDM®-based 3D printers and 3D production systems to create custom manufacturing tools often experience lead-time reduction of 40 to 90 percent.

3D printing increases return on investment by reducing the cost of a jig or fixture. Typically, companies realize savings of 70 to 90 percent when compared to outsourced fixtures that are machined or fabricated. For Thogus' 12-cavity fixture, the savings were 87 percent. "The machine shop wanted $1,500 for the fixture. I made it for less than $200 in materials," said Williams.

With 3D printing's flexibility, manufacturers can create their own tools as a permanent solution or as a stopgap measure. For example, a manufacturer who has to wait weeks for an injection mold to arrive can produce that mold in-house and take advantage of bridge manufacturing to get to market sooner.



Creating injection molds (top) and metal forming tools (bottom) on an in-house 3D printer is typically faster and less expensive than outsourcing them to a machine shop.

REPLACING HEAVY METAL

Traditionally, tooling has been crafted from metal using techniques such as milling. It's an expensive, time-consuming process that often must be outsourced to a machine shop. By opting for 3D printed plastic tooling instead, manufacturers can save money, put the tool into use on the factory floor sooner, and even improve its design for greater efficiency and better ergonomics.

Because 3D printing can create designs that cannot be manufactured by milling, tools can incorporate enclosed hollow areas that reduce material use and weight. Plastic tools are also lighter than their metal counterparts by nature, a benefit that can reduce worker fatigue.

At BMW, engineers have discovered that there are even greater advantages from the design freedom that 3D printing offers. Engineers Günter Schmid and Ulrich Eidenschink used 3D printing to make ergonomically designed assembly aids that perform better than conventionally made tools.

To improve productivity, worker comfort, ease of use and process repeatability, the plants used 3D printing to enhance the ergonomics of its hand-held assembly devices. The engineers created tool configurations to improve handling, reduce weight and improve balance. According to Schmid, "The tool designs we create often cannot be matched by machined or molded parts."

In one example, BMW reduced the weight of a device by 72 percent with a sparse-fill build technique. Replacing the solid core with internal ribs cut 1.3 kg (2.9 lbs) from the device. "This may not seem like much, but when a worker uses the tool hundreds of times in a shift, it makes a big difference," said Schmid.

THE RIGHT TOOL FOR THE JOB

"A 3D printed tool can last as long as the metal version, but you do have to understand what the best use is for the technology," said Ryan Sybrant, business development manager at Stratasys. "We're not saying 3D printing is going to cannibalize CNC or injection molding, but for applications when you can use it to optimize production and be more economical, it's absolutely the right choice."

Modern materials yield sturdy 3D printed tools that can resist petroleum, solvents and temperatures of up to 390°F. "There are tools that have been on factory floors for years," Sybrant affirmed. "But if a tool does wear out or break, a replacement can be created overnight."

That speed also gives manufacturers a new workflow option: digital warehousing. Instead of storing an infrequently used metal tool, workers can print a plastic version, discard it when the need has passed, then print another from the stored digital file. "Inventory space is a luxury, and it costs time and money to track tools all the time," said Sybrant.

PARTS: END-USE QUALITY

In addition to prototypes and tooling, modern 3D printing technology can produce durable, stable end-use parts — bypassing the production line altogether. The Production Series from Stratasys uses a range of materials, including production-grade thermoplastics, to create parts with predictable mechanical, chemical and thermal properties.

"Low-volume production is a market segment that traditionally hasn't been covered well," Sybrant noted. "Most injection molding houses, for example, won't take an order under a set number of components, or they charge a high fee to make it worth their while. It often makes more sense to complete the job in-house instead."

Whale, based in Northern Ireland, manufactures and exports pumps and drainage devices for mobile applications. Injection molding is a core competency for Whale. In the past, Whale outsourced its injection molding prototyping to service bureaus and often ordered the parts from as far away as China.

Whale began investigating the possibility of using 3D printing for injection molds. Despite initial skepticism, they found Digital ABS had the ideal properties for low-volume part production — high temperature resistance and toughness.

Prior to acquiring 3D printers, Whale's metal injection molding tools took four to five weeks to produce and cost tens of thousands of pounds sterling. These tools are now designed during the day, 3D printed overnight and tested the next morning with a range of end-product materials.

Patrick Hurst, the managing director at Whale, explained, "We have already seen the technology take months off of our product development process and that in turn minimizes risk. In fact, I estimate that we've shortened our R&D process by up to 35 percent with 3D printing solutions. Add that on top of the 20 percent we're already saving in terms of our design work — well for me, it's fantastic."

THE MAGIC NUMBER

What size of production run is appropriate for 3D printing? "That depends on the size of the items," explained Sybrant, who has seen production runs for 2,500 pieces. Wohlers said, "It is usually in the tens or hundreds, but the quantity can vary greatly, depending on the value, size and complexity of the parts."

These functional prototype diaphragms were made with Santoprene using a 3D printed injection mold (foreground). The CNC tool previously used to create the same part is shown in the background.

Kelly Manufacturing Company (KMC), the world's largest manufacturer of general aviation instruments, makes the R.C. Allen line of aircraft instrumentation. It used 3D printing to modify a toroid housing in a turn-and-bank indicator. Previously, these parts were made from urethane molded in soft, rubber tooling. This was the process of choice for low-volume production, because it's much cheaper and faster than a composite layup. But 3D printing has replaced rubber molding since it further reduces cost and time.

The toroid housing, cast in a rubber mold, would have taken three to four weeks for a 500-piece order. Now KMC produces 500 toroid housings in one overnight run of its FDM system. Justin Kelley, KMC president, said, "From order to delivery, it takes only three days to have certified production parts."

As Wohlers explained, the items in a single run "can be similar yet different, as in the case of dental copings (for crowns and bridges), plastic dental aligners (for straightening teeth), and in-the-ear hearing aids. With these examples, thousands of parts are produced, yet each one is unique in shape and size."

Wohlers Associates said overall mass customization growth accelerated to 34.9 percent in 2013. Analyst firm Canalys pegs

500 toroid housings are produced overnight with a Fortus 3D Production System.

the market will expand by 45.7 percent annually from now till 2018, and consumer products will help drive gains.

VERSATILITY: BENEFITS FOR MANUFACTURERS OF ALL SIZES

Large organizations can benefit from 3D printing — but so can smaller companies. This technology allows them to compete with much larger competitors because they can be more agile and possibly quicker to market. 3D printing can also lower their cost to market and improve the quality of designs.

"Advances in technology are yielding faster print times and enabling objects to be printed in greater combinations of materials, colors and finishes," said Canalys senior analyst Tim Shepherd in a press release. "Crucially, prices are also falling, making the technology an increasingly feasible option for a broad variety of enterprise and consumer uses, restricted only by computer-aided design competencies and printer availability — both of which are set to improve significantly."

The pattern of adoption and implementation are clear: 3D printing accelerates change in manufacturing, and companies should embrace and learn to leverage this technology. Regardless of the size of their focus, manufacturers need to improve their product quality and their speed to market. The prototyping, tool creation and short-run production capabilities of 3D printing technology can help them achieve these goals.

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