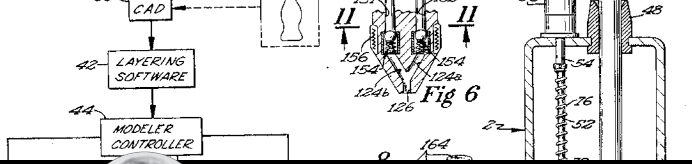


HEAVY INDUSTRY

Written by Joseph Kowen and Terry Wohlers

Large, fast, and exotic, professional 3D printers make serious parts

Alex Schroff for GE Reports, NASA/MSFC/Emmett Given, NASA/MSFC/David Olive

JOSEPH KOWEN, an associate consultant at Wohlers Associates, holds a law degree from Hebrew University in Jerusalem, Israel, and an MBA from Case Western Reserve University.

TERRY WOHLERS is an industry consultant, analyst, author, and speaker. He is president of Wohlers Associates, an independent consulting firm he founded 30 years ago.

Patents grant inventors a monopoly until they expire. Upon expiration, everyone can apply the invention to new products without limitation. All of today's fused deposition modeling (FDM)–like desktop 3D printers can trace their technological roots to a 1992 patent by Scott Crump. Thanks to Crump's inventiveness, millions of people worldwide now have access to inexpensive versions of his original idea.

Stratasys, the company Crump founded, continues to produce industrial 3D printers based on the same concept. The top-of-the-line machine today can print parts as large as 36"×24"×36" using a range of materials. Parts made in ULTEM 9085, for example, are used extensively in aircraft from Boeing and Airbus. The list price of the system? $400,000. Yet customers continue to buy such pricey machines because of the demanding applications and material properties that their businesses require.

The average selling price (ASP) of an industrial 3D printer is $104,222, according to *Wohlers Report 2017*. The ASP for printers that produce metal parts is $566,570. Meanwhile, the ASP for desktop machines that sell for under $5,000 is $1,094. Both the low and high end share the basic process of producing parts layer by layer, but they are really two very different animals.

At the time Crump was developing the FDM process, other pioneers were inventing different methods of 3D printing. Stereolithography, in which light is used to build parts by selectively curing photopolymer, is still a popular method among industrial users for producing a wide range of parts, large and small. With the expiration of basic patents for this process, simple vat photopolymerization printers are available today for $3,500. 3D Systems, the company to first commercialize the process, still sells large stereolithography systems for up to $990,000.

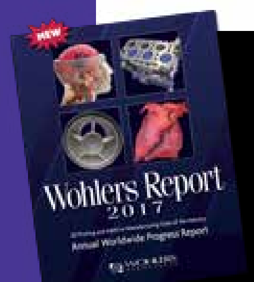
3D printers based on the powder bed fusion process use a laser to melt layers of powder to build up high-performance, functional parts. Originally developed to produce plastic pieces, the same process is now at the heart of the hottest area of additive manufacturing (AM): melting metal powder to build fully functional metal parts.

INDUSTRIAL OUTLOOK

Manufacturers see AM as a next-generation tool for production parts, a $12.8 trillion global business.

Materials: Today's 3D printers can print in a long list of plastics that includes nylons, elastomers, silicones, Kevlar, carbon fiber–filled plastics, and even biocompatible materials. Industrial companies print nickel, titanium, and precious metal parts for jet engines, dental crowns, spare parts for automobiles, and even jewelry. Ceramic parts and foundry sand for casting metal parts are also printed routinely.

THE INDUSTRY BIBLE



Anyone with serious interest in professional 3D printing should be reading the *Wohlers Report*, an annual tome that outlines the state of AM, ranging from the largest tool makers down to the desktop machines that frequently grace the pages of *Make:*. The 2017 edition contains 343 pages of useful, up-to-date information that includes breakdowns of just about everything additive, including software options and material properties offered by printing vendors. At just under $500, it's not a casual purchase for hobbyists, but there's no better resource for anyone in the business of digital fabrication.

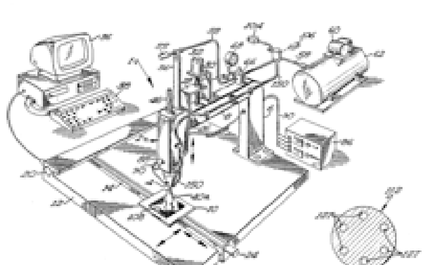
—Mike Senese

Size: The Big Area Additive Manufacturing (BAAM) system, manufactured by Cincinnati, can build parts of up to 240"×90"×72", extruding thermoplastic materials at a rate of 80 pounds per hour. One would need to run 2,725 Ultimaker 3 desktop 3D printers to reach the same volume as one BAAM system.

Throughput: Today's industrial 3D printers are capable of producing parts in quantities and at speeds that begin to compete with traditional manufacturing processes for short-run production. Wohlers Associates calculates that one would need 163 Ultimaker 3 machines to match the output of *one* HP Jet Fusion 4200 printer. A service provider in California announced that it can produce 600,000 small parts weekly with six of these machines from HP. No molds are required, allowing production to begin as soon as a design is complete.

Applications: NASA's Marshall Space Flight Center is using metal AM to produce ignitors, injectors, combustion chambers, and turbopumps for next-generation propulsion systems. GE is using the technology to produce LEAP engine fuel nozzles that are 25% lighter, last 5 times longer, and are easier to manufacture, and the company has the capacity to manufacture tens of thousands of the 3D printed nozzles annually. GE also redesigned the engine for the CT7 helicopter, determining that it could print up to about 40% of the engine. With AM, the company was able to reduce 900 individual parts to just 16 and reduce weight and cost by around 35%.

The good news for makers is that much of what industrial system manufacturers learn today becomes public knowledge tomorrow. When patents expire, energetic entrepreneurs waste no time in packaging these processes for the broader public. In fact, it is already well underway.



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