Direct Digital Manufacturing Part Four Industries and Applications

By Scott Crump, CEO, Stratasys, Inc.

Figure 1: The Stratasys FDM 900mc manufacturing system. 32 components on this system manufactured using DDM.

Direct digital manufacturing (DDM) is being applied in a diverse range of industries. Examples of DDM success are found in aerospace, automotive, consumer products, electronics and defense. Each of these industries, and many others, has applied DDM, and each will continue to see an increase in the number of DDM applications.

Interestingly, DDM has a broader reach than just traditional manufacturing. For example, the medical and dental industries have been early adopters of DDM In some cases, traditional manufacturers may learn a few things from these non- traditional sources. By observing other industries that have adopted DDM, companies can gain insight into innovations that leverage the advantages of the process. One such example is the mass customization that makes DDM so attractive to the medical arts.

To bring DDM to life, four real world examples are offered. Each application brief shows that DDM is much more than a concept or a distant vision of the future of manufacturing. “Practicing what it preaches,” the first example of DDM applications comes from Stratasys’ internal use of its fused deposition modeling (FDM®) technology.

Stratasys, Inc.

Stratasys has implemented many DDM operations over the past few years. Its FDM technology is used both to manufacture production parts and to make fabrication and assembly tools.

The most recent application of DDM for the manufacturing of FDM machines was on the FDM 900mc™. In total, 32 components on this machine were manufactured with the DDM process (figure 1). In a few instances, DDM was used to preserve delivery date commitments, in others it was used to improve product functionality and still in others it was used to reduce manufacturing costs.

Figure 2: FDM 900mc display bezel manufactured on an FDM 900mc.

Perhaps the most notable application was for the manufacturing of the display bezel on the front of the machine. Historically, this component was fabricated in sheet metal because the cost of tooling for injection molding was not justifiable for the low volume of machines that are manufactured. The estimated cost to construct molds for a bezel was nearly $100,000, and it would have taken two to three months to complete the tool making process. With DDM, Stratasys gained the advantages of a plastic component without the cost and time required for molding. The result was a part that was designed solely for form and function.

The display bezel illustrates both the freedom of design and freedom to redesign (figure 2). Originally conceived and developed as a single piece with intricate details, it was discovered— late in the design cycle—that the single component design would create difficulties when servicing the display panel and increase repair costs.

To rectify the situation, the bezel was segmented into three separate pieces This design revision facilitates simple disassembly and dramatically reduces replacement costs. While "part consolidation" is a big advantage of DDM, the display bezel illustrates that the opposite is also true. If the bezel had been produced from tooling, it would have been prohibitively expensive to explode the single component into three pieces that required three injection molds.

When asked about the advantages of DDM, the design engineering team also noted that it enjoyed the flexibility that DDM introduced into the design schedule. Rather than working within a strict timeline with penalties for changes late in the design cycle, the design engineers found that they were continuing to modify components designs, for performance and cost, well into the product development and manufacturing cycle. These modifications continued beyond the FDM 900mc product launch date. Unlike traditional manufacturing, the design is always fluid—it is never frozen—because changes can be incorporated before each and every run of an FDM machine.

While a bit more mundane, an equally important DDM application is the production of fixtures, jigs and assembly aids. The manufacturing engineering team has adopted DDM in their standard practices because it requires less effort, less time and less money. With DDM the manufacturing engineers design new fixtures and put them into service the next day. When limited to CNC machined fixtures, similar projects would take two to six weeks. Expediting the process, DDM allows manufacturing engineering to be much more responsive to the needs of the manufacturing floor.

Figure 3. At BMW AG, Regensberg, an FDM system is used to rapid manufacture assembly tools like the one above.

Another important factor is that the DDM solution demands less time and effort from each manufacturing engineer. If fabrication and assembly tools were machined, the engineer would invest significant time to document a part in a detailed CAD drawing, solicit quotations for the machining, place an order, manage the vendor and assembly the fixture upon receipt. Using their FDM machines as DDM devices, fabrication and assembly tools are produced with only a few minutes of the engineers' time.

BMW

Like Stratasys, BMW has used DDM extensively for fabrication and assembly tools. BMW's department of jigs and fixtures (at its AG facility) has stated that DDM is a good alternative to the conventional metal cutting manufacturing methods like milling, turning and boring. This team has documented financial advantages, including cost reductions in engineering documentation, warehousing and manufacturing. However, the most important advantages have stemmed from the design freedoms that DDM offers.

In many instances, BMW has manufactured ergonomically designed assembly aids that perform better than those that could be made with traditional methods. For example, a hand-held alignment tool made with FDM delivered greater worker productivity, less worker fatigue and more process repeatability. The assembly aid designer was able to manufacture a design configuration that had better balance and was 72% lighter.

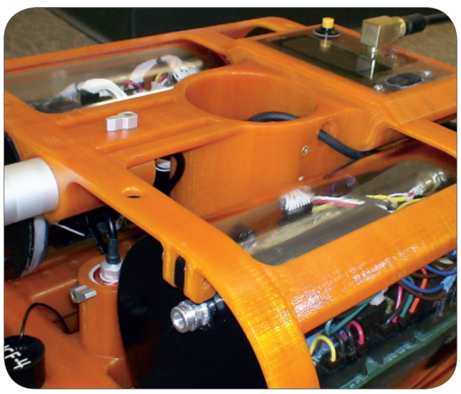

Figure 4: At UCF The frame was first prototyped, then manufactured from ABSi using the same FDM system.

For many companies, fabrication and assembly tools are ideal for first attempts at implementing DDM. These devices prove to be low-risk, high-reward applications of DDM. Fixtures also help to illustrate the possibilities that DDM offers. They can make the intangible concepts real. When people see DDM in action, they can easily grasp what it is and what it can do. This spawns creative ideas and new applications.

University of Central Florida

Shifting from the manufacturing floor of Stratasys and the assembly lines of BMW, DDM applications take to the seas with a project at the University of Central Florida. The university participated in an autonomous, underwater vehicle competition. Its entry, named Scout (figure 4), leveraged the advantages of DDM to take the "best new design" honor.

Figure 5: Designed for an for an offshore oil-drilling rig, this drill-operator control chair was prototyped with an FDM system. Then 25 of its components were manufactured by the same system.

In the previous year's competition, the design team used a vacuum molded shell that wasted space and was too heavy. Also, process limitations made it impossible to include brackets and compartments in the molded part. At first, the team pursued a machined component as an alternative, but they were told by several machine shops that the geometry was so intricate that it would be impossible or prohibitively expensive to machine. This motivated them to turn to FDM so they could DDM the underwater vehicle's shell. The new design was vastly superior to the vacuum-molded predecessor. According to the design team, the FDM shell reduced the total number of components, cut the vehicle's weight, and increased its strength while costing less.

NORSAP

NORSAP manufactures furnishings and equipment for the marine and offshore industries that are low-volume, high-value applications. The company had purchased an FDM machine with the intent of using it 80% for prototypes and 20% for manufacturing (DDM). Once in operation, the company found that it used its additive fabrication technology 80% of the time for DDM of its high-value products.

An early DDM application arose when the company was manufacturing a new helmsman chair that was to be put into service in the North Sea. Like much of NORSAP's product line, the helmsman chair was customized for the specific client. For this chair, the company had a brand new design and only days to deliver it. Having just completed FDM prototypes of some intricate components, NORSAP realized that there was no reason why they could not be used as production parts. The rapid response allowed NORSAP to deliver the chair on time.

This early DDM success was the catalyst to the FDM machine being used primarily for production applications. Today, NORSAP is running their machine around the clock, 7 days a week, and it does so with very little operator oversight. Generally, their DDM production parts are ready one day after the design is completed. According to a NORSAP employee, "{DDM is} nothing short of revolutionary."

Through Stratasys, BMW, University of Central Florida and NORSAP, the power of the direct digital manufacturing process can be seen. For NORSAP, the advantage is lead time reduction and product customization. For the University of Central Florida, the advantage is design alternatives that were previously impossible. For BMW the advantage is new design paradigms, higher performance and cost reduction. And for Stratasys, it is all of these advantages coupled with a faster response from manufacturing engineering and freeing up its most valuable asset, its talented staff of employees.

DDM will be the next industrial revolution because it offers companies an unprecedented freedom to innovate their products, processes and businesses.

The FDM Process

FDM® is an additive fabrication process used for both prototyping and direct digital manufacturing of thermoplastic parts. Following a toolpath created from CAD data, the FDM machine extrudes plastic in layers as fine as 0.005 inch (0.127 mm), building a part from the bottom, up. The process uses ABS, polycarbonate, sulfones, and blends.

FDM System Info:
www.stratasys.com

Product Inquiries:
E-mail: info@stratasys.com
Phone: 888-480-3548

For more information about Stratasys systems and materials, contact your representative at +1 888.480.3548 or visit **www.stratasys.com**

Stratasys Inc.
7665 Commerce Way
Eden Prairie, MN 55344
+1 888 480 3548 (US Toll Free)
+1 952 937 3000
+1 952 937 0070 (Fax)
www.stratasys.com
info@stratasys.com

Stratasys GmbH
Weismüllerstrasse 27
60314 Frankfurt am Main
Germany
+49 69 420 9943 0 (Tel)
+49 69 420 9943 33 (Fax)
europe@stratasys.com

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