DIRECT DIGITAL MANUFACTURING PART ONE: WHAT IS DIRECT DIGITAL MANUFACTURING?

Stratasys
FOR A 3D WORLD

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After 20 years, the future has become a reality. Additive fabrications technologies, which until recently have been relegated to rapid prototyping applications, have entered into the manufacturing realm. The use of additive fabrication processes is what differentiates direct digital manufacturing (DDM) from conventional manufacturing methods, and it is from these technologies that unique advantages and opportunities arise. Direct from 3D digital data, a component is manufactured—layer-by-layer—without machining, molding or casting.

A common question that is asked is, "What is DDM?" The question arises because consensus on many aspects of the process, including what to call it, is lacking. Over the past few years, the term direct digital manufacturing has become more commonplace. Yet, alternatives are still routinely used. When discussing DDM, many will use terms such as rapid manufacturing, additive manufacturing or free form fabrication; all of which are synonymous to DDM. Stratasys, Inc., has elected to adopt DDM because this terminology clearly distinguishes the technology from all others. Additionally, this decision supports the Society of Manufacturing Engineers (SME), which has endorsed DDM as the preferred name for this unique manufacturing approach.

As the name implies, DDM is a process that uses additive fabrication technologies, such as FDM, to manufacture parts. In other words, DDM produces the components that go into the products that a company sells. Yet, the concept is still maturing so there is some disagreement as to what the scope of DDM is and how to define it. However, at Stratasys, DDM is defined as a process that is used to perform one of the following three manufacturing functions:

- Manufacture end-use, sellable goods: The manufactured items are the components and subassemblies that go into the products that a company sells to its customers. (Figure 1)
- Produce end-use items that are used by the manufacturer: Rather than making a company's products, the process is used to manufacture devices that aid in the production of the sellable products. These fabrication and assembly tools include jigs and fixtures. (Figure 2)
- Create tooling for the molding, casting or forming of products: This application can be either the direct production of tooling, or the indirect creation of tooling from a pattern, that is constructed from an additive fabrication technology. (Figure 3)

Figure 1: Klock Werks Bezel

Figure 2: BMW Jig

Figure 3: Injection Blow Molding in polycarbonate plastic

AN INDUSTRIAL REVOLUTION

The shift away from the term rapid manufacturing is due to two factors. First, many conventional processes have begun using the term "rapid manufacturing" to describe the activity whether or not it incorporates additive fabrication technology. This has rendered the term somewhat meaningless. Second, and more importantly, DDM offers much more than an acceleration of the manufacturing process. An emphasis on "rapid" can lead to oversight of the numerous advantages delivered throughout the manufacturing process. DDM is not a simple revision of existing manufacturing methods that makes the process faster. It is a radical departure that fundamentally changes manufacturing.

With the enormous shift will come new ways of thinking, new processes, modified work flows and innovative procedures. DDM presents a radical departure that allows designers, engineers and manufacturers to do what was previously impractical or impossible. DDM has opened the door for new product designs, new markets and new business models. It is a radical departure that affects more than design and manufacturing engineering. It has broad impact throughout the entire organization. For these reasons, DDM has been labeled as the next industrial revolution.

For DDM to live up to this vision, for it to become the next industrial revolution, it has to be positioned properly and implemented correctly. DDM must be viewed as an alternative to traditional manufacturing methods rather than a replacement technology. DDM is not a global replacement for manufacturing processes that are performing as needed, expected or desired. DDM is not a cure-all or a magical solution to all of the ills on the manufacturing floor. Rather,

DDM is an alternative that should be considered when the limitations and constraints of existing manufacturing methods impact the ability to manufacture a desired product practically, efficiently or affordably.

DDM creates an opportunity for companies in a diverse range of industries to realize significant benefits (figure 4). At present, it is a viable process for innovative individuals and progressive companies that use DDM to address specific needs to achieve goals that were previously unattainable. For these companies, DDM represents opportunity. For others, it creates new threats. For example, large, established corporations have a new source of competition. The small start-up has a tool that facilitates entry into new markets with new products while enduring much less risk. In fact, many of the innovative applications of DDM are arising from the entrepreneurial pool where business plans are based on, and new business models are built upon, the unique advantages of DDM. These entrepreneurs have a tool that may position them to be new competitive threats to established businesses.

Whether or not a company plans to implement DDM in the short term, it needs to stay abreast of the technologies, advancements and applications. The next industrial revolution may not have arrived, but it is coming.

Figure 4: A roller arm fixture assists in assembly. Versus CNC and EDM, there was a 94 percent cost reduction when made with the FDM process. Cost estimate of part pictured:

Estimate using CNC method:
Cost: $2,300
Delivery 3 - 6 weeks

Estimate using FDM process:
Cost: $300
Delivery 1 - 2 days

DDM CONCEPTS AND BENEFITS

The primary advantage of DDM is that it removes constraints imposed by traditional manufacturing processes, such as injection molding or die casting. DDM fundamentally alters many of the "facts" that are taken for granted during the efforts to design, manufacture and assemble a product. If also shifts the logic applied to business decisions in the sales, marketing and finance departments as well as those in the executive suite. Because DDM imparts fundamental changes, many have difficulty grasping the key concepts and benefits.

To appreciate what DDM can do for a manufacturing company, an understanding of the fundamental changes that it imparts is necessary.

Time-to-market is no longer constrained by the lead time for tooling. Since DDM eliminates tooling, a product may be manufactured the same day that a design is completed. This allows companies to respond faster and to do so with less initial cash outlay for tooling and capital equipment.

Product design is no longer constrained by the rules for design for manufacturability (DFM) or the rules for DFA (design for assembly). Since components are manufactured using additive fabrication technologies, such as FDM, there is no limit to design complexity. Complex parts are made without additional expense or production delays.

Product revisions are no longer constrained by inventory levels, expense for new tooling or the time for tooling rework.

Because there is no tooling, short-run manufacturing principals may be used. This on-demand strategy reduces inventory levels and minimizes losses when product modifications are implemented (figure 5). Also, companies may change the design at any time, and as frequently as desired, so that products remain innovative, optimized and cost effective. Manufacturers no longer face the difficult decision of postponing a desperately needed modification because of lost time and high expense.

Figure 5: Short-Run Manufacturing

Production schedules are no longer bound to inaccurate sales forecasts or rigid economic order quantities. The on-demand, just-in-time manufacturing practice promoted by DDM, diminishes the need to build a production schedule from a sales forecast that is in the too distant future to be reliable. Additionally, unlike traditional manufacturing methods, there is no time consuming set-up or change over. Therefore, there is no penalty for frequent product changes in the manufacturing schedule.

DDM changes the basic tenets that have been held strongly for decades. It offers a fundamental shift in the way products are manufactured. Time-to-market, freedom of design, freedom to redesign and flexible manufacturing plans are only the beginning. These advantages represent just the tip of the iceberg. DDM is a relatively new manufacturing practice. As such, industry

and individuals have only just begun to discover the many ways that DDM can positively impact manufacturing. As DDM adoption increases and the application envelopes are expanded, industry will discover more uses for and more advantages from DDM.

The opportunities seem boundless. In fact, any limits that arise seem to be self-imposed. The implementation and advantages are limited only by our creativity, imagination and innovation. DDM is a radical departure from tradition. It is a revolutionary process, so open minds are needed. DDM is in its earliest stages, and there are many advancements waiting for us in the future. It is easy for opponents and critics to shoot down DDM when pitted against and established manufacturing method.

DDM is a revolution that will initially be built in an evolutionary way. To establish a foothold, it will start with incremental gains and niche applications. The full revolution is not here yet. For it to take place, improvements and advancements are needed in areas such s technology, equipment, materials and science. To facilitate the coming revolution, industry also needs more education.

Yet, DDM is viable today. Every day, companies are taking steps toward this future, and they are receiving immediate benefits. It will take time for the full revolution to occur; it will require agents of change; and it will demand open mindedness for industry to move towards the new reality in manufacturing. Direct digital manufacturing will deliver fundamental changes and sweeping advantages.

FDM PROCESS DESCRIPTION

Fortus 3D Production Systems are based on patented Stratasys FDM (Fused Deposition Modeling) technology. FDM is the industry's leading Additive Fabrication technology, and the only one that uses production grade thermoplastic materials to build the most durable parts direct from 3D data. Fortus systems use the widest range of advanced materials and mechanical properties so your parts can endure high heat, caustic chemicals, sterilization, high impact applications.

The FDM process dispenses two materials—one material to build the part and another material for a disposable support structure. The material is supplied from a roll of plastic filament on a spool. To produce a part, the filament is fed into an extrusion head and heated to a semi-liquid state. The head then extrudes the material and deposits it in layers as fine as 0.005 inch (0.127 mm) thick.

Unlike some Additive Fabrication processes, Fortus systems with FDM technology require no special facilities or ventilation and involve no harmful chemicals and by-products.

For more information about Fortus systems, materials and applications, call **888.480.3548** or visit **www.fortus.com**

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