STRATASYS

Direct Digital Manufacturing Part Two
Advantages and Considerations

By Scott Crump, CEO, Stratasys, Inc.

Direct digital manufacturing (DDM) is a new, unique alternative for the production of end-use items. Having little in common with traditional manufacturing methods, the uniqueness of DDM changes the decision-making process, overturns old principles and creates new criteria.

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" and principles that govern conventional manufacturing enterprises. Since DDM is an additive process that eliminates tooling, there are many advantages that simply are not available with traditional processes. Additionally, the additive processes introduce new considerations for gauging the viability of a DDM implementation.

Because it imparts fundamental changes, it is important to have a deep appreciation for both the advantages and limitations of DDM. With an understanding of the innovative benefits and unique characteristics of the process, companies can identify the manufacturing opportunities where DDM is a powerful alternative to conventional manufacturing methods.

Advantages of DDM

Rapid Deployment

When a component's design is complete, manufacturing can begin immediately. The lead time for first articles of finished goods is now measured in minutes and hours, not days, weeks or months. Just moments after the CAD data is complete, manufacturing can begin because there is no production delay while waiting for tooling. Instead of waiting six to 12 weeks to complete tooling design and construction, companies can simply export the CAD data as an STL file and begin production.

Figure 1: Components for this robotic gripper were first prototyped, then manufactured, using FDM (Fused Deposition Modeling).

The short cycle time for delivery of manufactured items aids in reducing time-to-market and preserves on-time delivery when last minutes challenges arise.

Low Capital Expenditure

Eliminating tooling not only reduces time-to-market, it also reduces the cost for manufacturing. Traditional manufacturing methods demand tools and dies that are expensive. With DDM there is no need for tooling. Therefore, the initial cash outlay to ramp up manufacturing is dramatically reduced. Additionally, other capital investments, such as those for new manufacturing lines, assembly lines or specialized manufacturing equipment may be avoided or minimized.

By reducing the initial outlay, companies can protect their cash flows, fund more new products and justify products for markets with low annual demand.

Unlimited Complexity

DDM promotes the design of parts for the best performance. Since DDM constructs parts with an additive fabrication process, like fused deposition modeling (FDM), the design complexity is unlimited. Design complexity is not only unlimited, it is free. There is no additional cost to manufacture sophisticated, intricate and complex designs. Also, the time to manufacture a complex part is no different than that for a simple design.

DDM breaks all of the rules associated with traditional manufacturing methods. The design for manufacturability (DFM) and design for assembly (DFA) rules that govern products made from traditional manufacturing methods no longer apply. Without these constraints, designs can take forms that were previously impractical or impossible.

With DDM, anything that a designer can envision can be manufactured. DDM lets the imagination run free; it promotes product innovation; and it allows design to be highly optimized for performance. Severing the relationship between design complexity, time and cost is a fundamental advantage of DDM that is called "freedom of design."

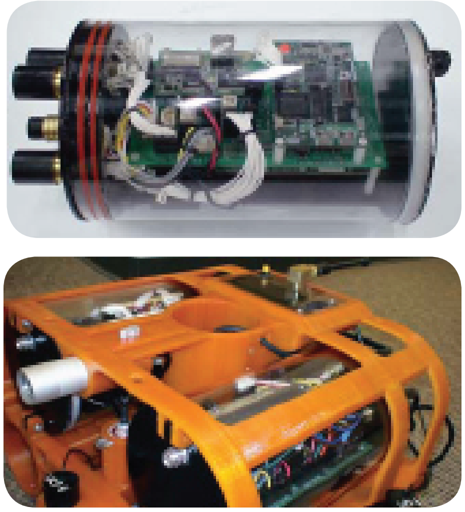

Figure 2 and 3 : University of Central Florida Electronics enclosure. The frame was first prototyped, then manufactured from ABSi using the same FDM system

Freedom to Redesign

Equally powerful to the design freedoms offered by DDM are the new-found freedoms to redesign a part at any time in the product lifecycle and as often as desired (figure 2 and 3). Since tooling has been eliminated, there is absolutely no penalty for product redesigns. A component may be revised without added manufacturing expense or production delay.

With traditional manufacturing methods, there is a point in the product development cycle where the design is "frozen." From that moment on, design revisions are unacceptable and are accommodated at great expense. With DDM, the design is never frozen. It is perpetually fluid and adaptable to the needs of the product, company and consumer.

Part Consolidation

Design for assembly (DFA) rules exist so that a collection of parts may be assembled easily and quickly with process repeatability. Each assembly operation takes more time and increases the possibility of mistakes. So, DFA rules seek to simplify assembly for the fastest manufacturing time, lowest cost and lowest scrap rate. The ideal design for assembly is one that completely eliminates assembly by consolidating all parts of a subassembly into one component. While this is often an unrealistic expectation when using conventional manufacturing methods, it is a very real possibility when a product is manufactured with DDM.

Part consolidation is an extension of the freedom to design. Since unlimited complexity is possible, multiple components may be consolidated into a single item with little concern for manufacturability. The positive impact on time, cost and quality are significant. Additional gains are discovered when the impact on supply chain management, production scheduling and inventory control are considered.

Figure 4: NorSap drill-operator control chair designed for an off-shore drilling rig.

Short-Run Manufacturing

For most conventional manufacturing methods, economic order quantities (EOQ) govern production scheduling and capacity planning. Considering tear-down and set-up, these manufacturing processes yield the lowest manufacturing costs when production runs exceed the predetermined minimum production quantity. The challenge is choreographing production scheduling, capacity planning and sales forecasts to produce the ideal number of products at the lowest cost with the highest efficiency. For large production runs, the ideal is rarely realized.

Short-run manufacturing is much easier to throttle to achieve production efficiency, cost reduction and target inventory levels. It is also much more responsive to changes in sales forecasts or manufacturing schedules. With DDM, companies have cost-effective, on-demand manufacturing that can react to the daily changes in manufacturing schedules without being penalized for unexpected changes.

Scheduling becomes easier, inventory management becomes simpler and inventory levels diminish without an increase in unit cost. Since there is no time consuming set-up or tear-down, the parts being manufactured in a DDM process can change with each and every build (figure 4).

Innovation

The fundamental advantage of DDM is that companies are free to innovate their product designs, business models, manufacturing processes and work flows. When leveraged to capitalize on all that it offers, DDM is much more than a substitute technology. When incorporated throughout an organization and fully embraced, DDM can change everything.

DDM imparts fundamental changes to manufacturing. In doing so, it also brings forth new considerations that are used to determine when, and how, to implement DDM in the manufacturing environment.

Considerations

As with every method, process and technology, DDM has constraints and limitations. If assessed in conjunction with the advantages, these considerations will assist in determining when a company should consider DDM.

Figure 5: Diebold ATM keypad privacy shield

1. Low Quantities

DDM is not a high volume manufacturing process. If demands are for millions of units a year, DDM will not be the right solution. Typically, DDM is used when production quantities range from one to 10,000 units per year (figure 5). The justifiable production quantity will vary with the size of the component. As part size decreases, the annual production quantity increases.

2. Output Qualities

Over the past few years, there have been technological advances that have improved the quality of parts produced through DDM. It is expected that these advancements will continue and that part quality will be further improved. But presently, there are a few characteristics that may differ from established expectations for high-volume production methods.

The first quality consideration is part accuracy. DDM is currently capable of holding accuracies that are approximately ±0.005 inch for small to mid-sized parts. Contrary to a process like injection molding, DDM is currently not capable of holding ± 0.001 to 0.002 inch tolerances across all features of a part.

Another factor is part-to-part repeatability. With the present state of the technology, as there is with all technologies to some degree, there is dimensional variance from run to run of the DDM machines. Also consider that without secondary finishing, the surface finish of a DDM part may not be suited for external components that demand high aesthetic value. Instead, the finish is more appropriate for internal components. However, surface finish should not be used to arbitrarily disregard DDM. For example, the FDM 400mc™ and 900mc™ systems have external parts that have been produced through DDM.

3. Material Characteristics

A final consideration is the properties of the materials that are available from DDM technologies.

While a technology like FDM offers real production grade plastics such as ABS, polycarbonate and ABS/PC blends, the material selection is much more limited than that for a process like injection molding. Stratasys has one of the broader ranges of materials with seven (is it eight now with ABS M30i?) distinct formulations, yet it does not come close to the hundreds of engineered plastics or metal alloys that are available for traditional production methods.

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:
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For plastics parts, also consider that there may be concessions with mechanical, electrical or thermal properties. Generally speaking, and when considering all DDM technologies, the material properties do not match those of the materials used in traditional manufacturing processes. For example, an FDM ABS material provides approximately 80% of the strength of an injection molded ABS part.

Conclusion

DDM is a process that allows companies to innovate product designs, business models and manufacturing processes. It lets engineers optimize designs and maximize performance. DDM can expedite product launches while eliminating tooling costs and tool lead times. And it frees manufacturers from the constraints of conventional processes, which allows the freedom to design complex items and freedom to change the design at any time.

Yet, as with all processes, there are some limitations. For DDM opportunities, look for low-volume production applications that can be adjusted to accommodate the constraints in quality and materials. For the next industrial revolution to occur, improvements and advancements are needed in areas such s technology, equipment, materials and science. Over the coming days, months and years, these advancements will take place. As they do, DDM will become more prevalent throughout more companies and in more products.

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

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Printed in the USA. DDM2 06/08

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