Direct Digital Manufacturing: Impact and Opportunity

Part 1—Freedom to Redesign

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Direct digital manufacturing is a process that employs additive fabrication technology (aka rapid prototyping) to produce end-use items. Directly from CAD data, components are manufactured without molding, casting or machining. The impact of direct digital manufacturing is far-reaching, and the opportunities and advantages are extensive. This is why direct digital manufacturing is heralded as the next industrial revolution.

Since the earliest days of rapid prototyping, experts have envisioned the application of the technology in the manufacturing process, and the focus of this vision has been on the initial cost and time savings that are realized when tooling is eliminated. Slashing hundreds of thousands of dollars and months from a product launch are significant benefits to manufacturers in all industries. However, the relative impact pales in comparison to the wide ranging advantages that exist when direct digital manufacturing is implemented.

Focusing only on the upfront benefits gained from eliminating tooling, industry has failed to recognize many of the opportunities that direct digital manufacturing offers. Some will yield unprecedented efficiencies; some will generate annual savings that far exceed the cost of a tool; and others will facilitate new methodologies that address age-old constraints imposed by conventional practices.
Direct digital manufacturing will benefit nearly every discipline within a manufacturing organization, and it will change fundamental business processes. When adopted en masse, it truly will be an industrial revolution.

Direct Digital Manufacturing

"Rapid Manufacturing" has become a generic term that is applied to any process that produces manufactured goods quickly. To avoid confusion, the Society of Manufacturing Engineers has adopted a new term, direct digital manufacturing. The association's definition of direct digital manufacturing is "The process of going directly from an electronic, digital representation of a part to the final product via additive manufacturing. "

In this series of white papers, the obscure, unrecognized benefits of direct digital manufacturing will be disclosed to reveal the huge potential that the process offers. Part 1 discusses the positive impact of a newfound freedom to redesign or alter products while in production.

STATUS QUO

For the production of moderate to high volume quantities of metal or plastic parts, molding and casting are the prevalent processes. However, the tooling that is required demands a sizeable investment and a significant commitment to the product and its design.

When adopted en masse, it truly will be an industrial revolution.

Direct digital manufacturing is an enabling technology since it eliminates the upfront expense and expedites manufacturing. For example, injection molds for small to moderate sized parts will often cost

$20,000 to $75,000 and take upwards of three months to complete. This investment of time and money is both a barrier to new products, especially for those with low forecasted demand, and a drain on the cash flow and profitability of a company. Obviously, since it eliminates the need for tooling, direct digital manufacturing facilitates new product launches and improves the corporate bottom line. For many, this is enough justification to pursue direct digital manufacturing, but bigger gains are derived from the freedom to change a product's design.

The rapid cycle times of tooling facilitate inexpensive manufacturing of thousands, often millions, of parts. When amortized over large part quantities, the cost of tooling becomes reasonable, and often times, almost insignificant. However, this presumes that tool will be operated for long periods of time, and therefore, the tooling becomes a liability. With the prospect of additional costs and delays, product modifications are undesirable. Investing $5,000 to $20,000 for tooling rework, or $20,000 to $75,000 for replacement, is an unwelcome expense. Also, the losses grow since sales revenues are nonexistent while waiting for tool repair. Therefore, wherever possible, the ideal situation is to produce a perfect tool and keep that tool running for the life of the product. With this aim, the release of a work order for a production tool becomes a major commitment.

However, the commitment is not reasonable. Product life cycles are shorter, consumer demand is more fickle and the odds of redesign are high. In effect, the commitment becomes justified only when perfection is achieved. Without the perfect product, perfect design and perfect mold, the investment in tooling becomes a constraint and an undesirable commitment. In many cases, when faced with less than ideal scenario, companies will opt to continue manufacturing the product without change. The cost and time of retooling outweigh the advantages of redesign.

The fundamental problem with tooling is that perfection is elusive, and striving for perfection is costly. It is unlikely that an organization is capable of perfection in every part, every assembly and every product that it makes. Oversight, error, assumptions and a whole host of unquantifiable variables can occur. Additionally, product demand may be overstated, and customer requirements may be misinterpreted.

Tooling is a constraint to making better products with better sales results.

Tools like rapid prototyping help companies to uncover flaws, errors and imperfections prior to releasing a production mold. And yet, problems still arise, only to be discovered when first articles are molded. In many cases, the problems are minor and can be ignored. In others, the flaws are significant, but repair is not an option due to cost and delays.

Tooling is commitment. The moment the order is released for tooling, the design becomes frozen. There is little latitude for change and alteration. The options are limited to reworking, retooling or building a stockpile of imperfect molded parts. Tooling is a constraint to making better products with better sales results.

FREEDOM TO REDESIGN

Direct digital manufacturing eliminates tooling and the associated constraints to changing a product's design. Since there is no investment of time and money in a tool, there is unlimited potential for product changes after it has been placed in production. With direct digital manufacturing, there is no penalty for error correction and no barrier to fine-tuning a design while it is in production. In fact, the process can facilitate rampant redesign that caters to rapidly changing consumer desires or counteracts competitive maneuvers.

In a direct digital manufacturing environment, product changes or design fixes are simply, efficiently and affordably implemented. With only a change to the CAD data, new variations of products are immediately ready for production. Redesign decisions are based solely on needs—not a multi-faceted decision matrix that considers manufacturing operations, tooling costs, opportunity costs and other effects on the business.

Direct digital manufacturing breaks the shackles of the constraints imposed by tooling and frees a company to make the best product possible. Although this is a simple statement, it has major ramifications for those companies that implement direct digital manufacturing techniques.

RETURN ON INVESTMENT

The value of freedom to redesign is immeasurable. It goes well beyond the standard accounting metrics that justify an activity or demonstrate a positive ROI (return on investment). This is because it delivers benefits that are difficult to measure, and it facilitates new business practices that benefit the company, its products and many design and manufacturing processes.

Yet, for those that require tangible, quantifiable measures, there are three financial calculations available for justifying direct digital manufacturing: initial savings on tooling, savings on rework and increased sales revenue. Using historical data, determine the typical expense for tooling and the cost of rework or replacement. Extrapolate these costs across all products made in a year. Then determine the typical delay in product delivery that is associated with tool making and tool rework. Multiply the number of days of lost sales times the anticipated daily sales, and multiple this result

ROI CALCULATION

Assumptions

Tool cost:	$30,000
Rework cost:	$7,500
Rework (percentage of tools):	25%
Number of tools per product:	15
Number of products:	10
Tooling delivery:	10 weeks
Rework delivery:	3 weeks
Annual sales per product:	$1,000,000
Gross profit:	50%

Profit Gains

Tooling:	
15 tools/product @ $30,000:	$150,000
x 10 products:	**$1,500,000**
Rework:	
15 tools/product @ 25% rework:	3.75
X $7,500 each:	$28,125
X 10 products:	**$280,125**
Sales:	
Weekly gross profit:	
$1,000,000/50 weeks:	$20,000
X 50% gross profit:	$10,000
X 10 products:	$100,000
Gross profit—tooling delivery:	
10 weeks @ $100,000:	**$1,000,000**
Gross profit—rework delivery:	
3 weeks @ $100,000:	**$300,000**
Total Profit Improvement:	**$3,080,125**

by the gross profit percentage. Combined, these factors represent the measurable financial impact of direct digital manufacturing.

As shown in the example, the potential for profit improvement is far greater than that from only the avoidance of investing in tooling. While this profit gain is impressive, even greater gains are available from those aspects that are difficult, or impossible, to measure.

<u>Process acceleration</u>

Since there is no penalty for imperfection, the entire design, testing and manufacturing process can be accelerated. Instead of investing time and money in making a product perfect in order to avoid cost and delays for rework, companies can shorten the entire development process. Instead of investing time to drive out the minor flaws and detect the small oversights, companies can proceed to the next phase earlier because of the inherent flexibility to alter a design at any time. In effect, there is little difference between a prototype, alpha test, beta test and finished product. All phases have no financial commitment to tooling, and therefore, no negative effects of change. Additionally, the design team will not be faced with the difficult decision of freezing a design that is not quite ready in order to meet product launch schedules.

The financial gain of this acceleration is difficult to quantify, and it will vary by company and product. However, it must be considered. When contemplating direct digital manufacturing, evaluate the financial gains, efficiency gains and process improvements in design, analysis, testing and manufacturing. Also, roll in the revenue gains associated with shortened time-to-market.

While it is never desirable to launch a flawed product quickly, direct digital manufacturing promotes process acceleration because there is always an option for redesign.

Fixes and enhancements can be introduced in each and every production run since there is no need for tooling rework.

<u>Continuous product improvement</u>

The stream of input for product enhancement is endless. Step back from any project for a few days— view it with fresh eyes—and previously undetected errors or opportunities for enhancement will leap out. Put product in the hands of customers, and they will provide feedback over the life of a product. Direct digital manufacturing allows companies to incorporate these observations and inputs as they are discovered. Fixes and enhancements can be introduced in each and every production run since there is no need for tooling rework.

Continuous product improvement will have a major impact on customer satisfaction, which in turn translates to increased sales. Also, making better products will reduce the expense for warranty and repair work. While obvious that sales will increase and service costs will decrease, it is difficult to quantify the huge financial gains that will result.

Decreased obsolescence and scrap

Since direct digital manufacturing does not have economies of scale associated with long production runs, the on-demand nature of the process means that there will be minimal work in progress (WIP) and finished goods inventory. This translates to decreased inventory carrying costs and minimal financial impact for product revisions.

In effect, forced obsolescence has little relevance in the decision to redesign a product since there is only a small amount of inventory to be scrapped. The financial impact of this advantage can be projected but not measured. For process justification, consider the cost avoidance of scrap and the potential sales growth from more frequent product changes.

CONCLUSION

When companies implement direct digital manufacturing, they will realize profit improvement, process acceleration, continuous product improvement and scrap reduction from the newfound ability to freely redesign a product at any stage in its life cycle. Although these benefits are difficult to quantify, the positive impact on a company and its products is obvious.

As shown, direct digital manufacturing can be justified solely on the freedom to redesign. However, there are many other advantages that the process offers. Throughout this series of whitepapers, these advantages will be discussed. Part 2 in the series will reveal the benefits of freedom of design. It will discuss the opportunities created when parts and assemblies are no longer constrained by design for manufacturability rules.

Direct digital manufacturing will be the next industrial revolution. With it, as with any revolution, there will be a total upheaval, a radical change and an overthrow of existing practices. Direct digital manufacturing will infiltrate all processes and every discipline within a company. It will change how manufacturing is done.

About the Author

Todd Grimm is president of T. A. Grimm & Associates, Inc., an independent consulting firm that focuses on rapid prototyping and reverse engineering. Todd has worked in the field of rapid prototyping since 1990. He is the author of "Users Guide to Rapid Prototyping" and holds a Masters Certificate in Rapid Prototyping. Todd serves on the Society of Manufacturing Engineers' Rapid Technologies and Additive Manufacturing steering committee, and he chairs the 3D Data Capture/Reverse Engineering technical group.