Direct Digital Manufacturing: Impact and Opportunity

Part 4—Jigs & Fixtures

Compliments of:

www.RedEyeRPM.com

By Todd Grimm

T. A. Grimm & Associates, Inc.

www.tagrimm.com

PREFACE

Direct digital manufacturing, otherwise known as rapid 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. However, the relative impact pales in comparison to the wide ranging advantages that exist when rapid manufacturing is implemented.

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. 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 often unrecognized benefits of direct digital manufacturing are disclosed to reveal the huge potential that the process offers. Part 1 discussed the positive impact of a newfound freedom to redesign or alter products while in production. In Part 2, the discussion highlighted direct digital manufacturing's elimination of design constraints imposed by conventional processes. Part 3 investigated direct digital manufacturing's role as a bridge to production. Part 4 shows that the advantages described in the first three parts are also available for indirect manufacturing applications; "indirect" because the process is not used to make products. Instead, it is used to produce jigs & fixtures

STATUS QUO

The prime concerns of manufacturing engineers are productivity and quality. The daily challenge is to ensure maximum production quantity while adhering to the specified quality standards. Jigs & fixtures are essential tools to achieve these aims.

Although they are essential and abundant, jigs & fixtures (collectively referred to as "fixtures") are virtually transparent when production is running smoothly. Few people in a company give fixtures any thought until there is a quality problem or production delay. When a problem does arise, their critical role becomes obvious, and manufacturing engineering scrambles to devise a quick fix to keep production rolling. However, new fixtures can take weeks to produce, so manufacturing engineering may be forced to put a bandage on the problem and hope for the best.

> Definition: Jigs & fixtures are devices that locate and hold work pieces in manufacturing. The characteristic that distinguishes one from the other is that jigs guide or locate tools; fixtures do not.

For a relatively simple fixture, the lead time can be hours, but making moderately complex designs can take two to four weeks. Typically, fixtures are made of plastic or metal and are produced by a machining or fabricating process. For these manufacturing methods, time and cost increase as the fixture becomes more complex.

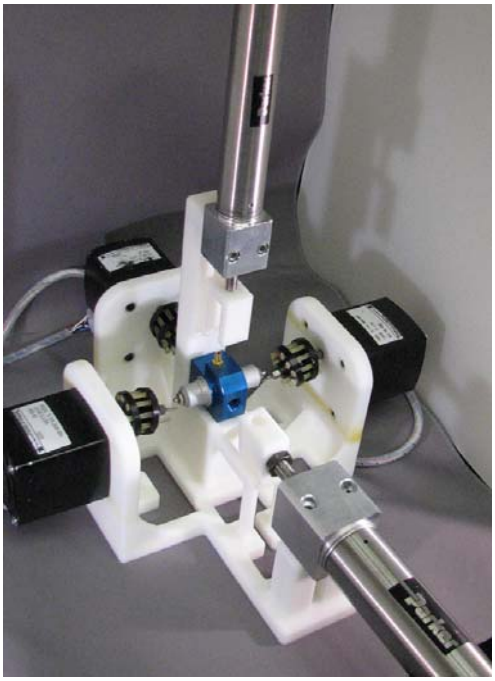
The manufacturing process also places constraints on a fixture's design. Design for manufacturability (DFM) and design for assembly (DFA) rules apply to fixtures, just as they do for product design. In light of these constraints, fixtures may not be optimized for performance. Instead of designing to the application's needs, the fixture is designed to satisfy machining or fabricating constraints.

Producing fixtures is not a simple task. It involves all of the stages of product development, beginning with design and documentation and progressing through manufacturing. Throughout the process, the manufacturing engineer communicates with the shop and manages the project. Ideally the development process also includes prototyping, testing and design iterations, but most often manufacturing engineers do not have the luxury of time to refine the design for optimal performance. Since the first iteration takes two to four weeks to complete, there is no time to devise the best solution.

The obstacles and constraints impede manufacturing engineering's goal of maximum throughput with the highest quality. These barriers prevent manufacturing engineering from rapidly implementing the best fixturing solution. Time also limits the number of fixtures that they deploy.

JIGS & FIXTURES

Fixtures are ideal "indirect" digital manufacturing candidates, especially for those that have yet to use the process for the direct manufacturing of products. Since cost and risk are minimal, and the potential value is high, applying direct digital manufacturing to fixture production allows companies to experiment and gain insight to the application possibilities and potential gains. These gains encompass all of the advantages described in the previous three parts of this informational series: freedom to redesign, freedom of design and bridging to a permanent solution.



Test fixture for a liquid oxygen valve. Freedom of design allowed consolidation of eight pieces and reduction of weight.

Fixture production is fast, simple and flexible when direct digital manufacturing is employed. It is quickly and easily implemented, and it is adaptable to changes in product designs. In the time it takes to receive a quote for a conventional process, direct digital manufacturing delivers fixtures that keep manufacturing rolling.

The moment a delay or problem is discovered, companies can devise a fixturing solution that can be implemented in as little as a day. All that is required is 3D CAD data, machine capacity and materials. Eliminating nearly all steps required in conventional processes, direct digital manufacturing minimizes labor demands and expedites manufacturing.

Direct digital manufacturing is not only fast; it is efficient. If provided direct access to a company's rapid prototyping machines, a manufacturing engineer can design and produce new fixtures independently. The "self-serve" nature of this process eliminates all dependencies on others' schedules, queues and priorities. Additionally, process automation allows the manufacturing engineer to multi-task; while building a fixture he can be working on other priority projects.

Process speed and efficiency will promote improved fixture designs. The manufacturing engineer now has the opportunity to prototype and evaluate multiple iterations of a fixture's design. The freedom of design offered by additive processes further improves a fixture's performance since it can be extremely complex without a time or cost penalty.

Direct digital manufacturing allows manufacturing engineering to respond rapidly to production challenges and product revisions. This satisfies the primary responsibility, maximize production throughput while delivering a quality product.

Tip: *Reduce worker fatigue and improve productivity with lighter hand-held fixtures. Removing unnecessary material, or making it hollow, will not increase the cost or time for fixture production with direct digital manufacturing.*

RETURN ON INVESTMENT

Financially, jigs & fixtures are as transparent as they are on the shop floor. They are included in a departmental budget line item that is rolled up into corporate financial statements as "tooling." The direct impact on production costs and sales revenues is difficult to determine and rarely attempted. So, there is no need to financially justify fixtures at the corporate level. Instead, the justification is determined by manufacturing engineering.

The number, type and complexity of fixtures vary from company to company and product to product. This makes it difficult to offer a return on investment (ROI) calculation for a typical company. Therefore, the following calculations are offered as examples from which manufacturing engineering could extrapolate its own returns.

At the departmental level, justification for fixtures can be quite simple. Those that use direct digital manufacturing for this application report savings of 50 to 75 percent, when compared to traditional machining and fabricating processes. So, if the typical fixture costs $500, direct digital manufacturing has the potential to produce the same item for $125 to $250. Coupled with the rapid response to manufacturing challenges, this cost reduction makes it is easy to justify direct digital manufacturing of fixtures.

Cumulatively, a $10 million manufacturer with 10 products could realize a savings of $37,500. This assumes that there are 10 fixtures per product and that the savings per fixture is $375. As the number of fixtures increases, so do the savings. For the manufacturing engineering department, the savings could be used to hire additional staff or add more fixtures, which will assist in achieving better throughput and quality.

ROI CALCULATION

Assumptions

Number of fixtures per product:	10
Avg, fixture cost:	$500
Lead time reduction:	8 – 19 days
Cost reduction:	50 – 75%
Number of products:	10
Annual sales per product:	$1,000,000
Gross profit:	50%

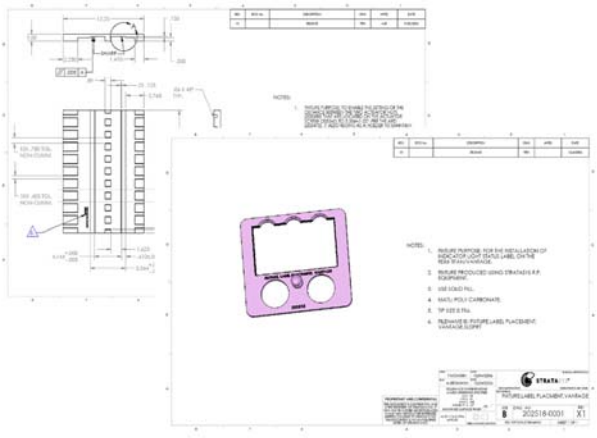
Profit Gains

Cost reduction:	
10 fixtures X $500:	$5,000
X 75%:	$3,750
Net profit:	
10 products @$3,750:	**$37,500**
Sales:	
Daily gross profit:	
$1,000,000/250 weeks:	$4,000
X 50% gross profit:	$2,000
Gross profit:	
Lead time reduction:	19 days
19 days @$2,000:	**$38,000**

Another avenue of financial justification is the prevention of delays in manufacturing products. Traditionally, fixtures can take two to four weeks to produce. With direct digital manufacturing, this lead time can be reduced to a few days. While it is unlikely that a single fixture would be allowed to stop production, if it did happen, a company would realize additional sales revenue and gross profit with a direct digital manufacturing solution.

For the sample company, the daily sales revenue per product line is $4,000, which yields a $2,000 gross profit. Should any one fixture stop production, direct digital manufacturing's rapid response would provide an additional eight to 19 days of production. This amounts to $16,000 to $38,000 per occurrence.

While the measurable savings are significant—at least on a departmental level— the intangible, difficult to measure results will capture the attention of executive management. Direct digital manufacturing of fixtures has an enormous impact on revenue and profit when productivity, efficiency, quality and throughput are taken into consideration.



Fixtures are expedited with elimination of time consuming steps such as creating detailed drawings (background).

Productivity & Efficiency

Within the manufacturing engineering department, direct digital manufacturing increases productivity and efficiency. This, in turn, allows manufacturing engineering more time to address issues that affect manufacturing's productivity, throughput and quality. The result is greater capacity, lower expense and higher profits.

In contrast to conventional methods, direct digital manufacturing decreases the time and effort of manufacturing engineering in fixture production. Instead of designing, documenting, quoting, ordering, scheduling, discussing and monitoring, the process is condensed to design and production. Excluding design, a manufacturing engineer need only to invest a few minutes to produce a fixture, even if he elects to make it himself. The hours saved are used to tackle other priority projects or to iterate the fixture design to maximize performance. Either way, plant floor productivity and efficiency are improved.

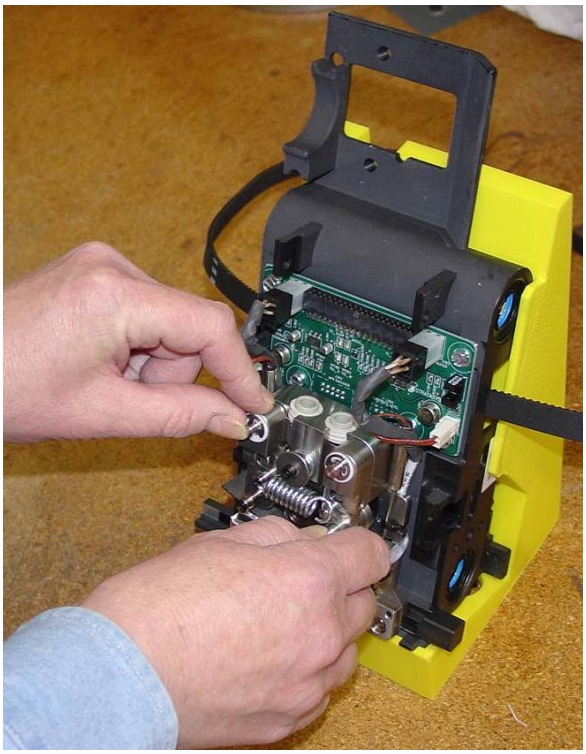
Manufacturing engineers need only to invest a few minutes to produce a fixture. Label alignment fixture shown.

Another consideration is that direct digital manufacturing removes design constraints. Having the ability to produce a complex fixture without time or cost penalty, manufacturing engineering can deploy optimized fixtures that may further reduce operational time or product rework. Additionally, what was previously impossible or impractical may be produce with direct digital manufacturing. For example, a handheld fixture can take on a freeform, organic shape that improves the balance. It can also be made lighter by hollowing out the fixture or adding numerous cutouts for material reduction. These possibilities offer the advantages of reduction in worker fatigue and operation cycle time.

Throughput & Quality

Increased productivity and efficiency on the plant floor directly translate to decreased cycle times and increased throughput. Having the freedom to optimize fixtures—without design limitations—improves production capacity, which reduces production costs and raises profits. Rather than implementing stop-gap measures due to the constraints of conventional practices, direct digital manufacturing enables manufacturing engineering to improve profitability with rapid deployment of the best fixturing solutions.

A well-designed, optimized fixture also yields repeatable, predictable quality. If a poorly designed fixture is deployed, process control may be lost and quality problems can occur. With elevated reject rates, scrap and rework increase, which decreases the plant's throughput, increases costs and reduces profits. If the quality issue makes it to the consumer, customer satisfaction diminishes, product returns rise and sales fall. Direct digital manufacturing prevents quality problems and the associated financial impact.



Well-designed, optimized fixtures yield repeatable, predictable quality.

Although they are virtually transparent, fixtures influence throughput, quality and profitability. They are an important tool for manufacturing engineering, because without them, all three suffer. In an ideal situation, manufacturing engineering would deploy as many fixtures as the manufacturing process warrants. However, the lead time, effort and cost of conventional machining and fabrication prevent manufacturing engineering from reaching this ideal. Since direct digital manufacturing is a fast, efficient and affordable alternative, manufacturing can have all the fixtures that are needed.

Adaptability

Throughout a fixture's life, it is subject to redesign, rework, repair and replacement. Redesign and rework are the result of product changes. Repair and replacement are needed when fixtures are worn or damaged. Whatever the circumstances, direct digital manufacturing provides a rapid response to these frequently occurring challenges.

Direct digital manufacturing provides a digital warehouse from which fixtures are "pulled." Rather than stocking spares in the advent of a damaged fixture, manufacturing can access the digital data to make a replacement. When lead times range from one to two weeks, this is inconceivable. But when a new fixture can be made in less than a day, digital warehousing becomes practical. With direct digital manufacturing, the expense of purchasing spares in advance and stocking them as inventory is eliminated. Direct digital manufacturing acts as a just-in-time (JIT) inventory methodology for fixtures.

The digital warehouse also facilitates redesign. If design engineering hands a product revision to manufacturing engineering, a modified fixture can be designed and rapidly reproduced. Accessing the digital CAD data, manufacturing engineering makes the design changes, exports an STL and transmits the data for building. In record time, the new fixture is put into service.

CONCLUSION

Fixtures are indispensable. They are a vital component in the continuous effort to improve manufacturing efficiency and product quality. Increasingly, direct digital manufacturing is becoming just as indispensible in the rapid deployment of more efficient and higher quality fixtures. Fast, simple and flexible, direct digital manufacturing addresses the daily challenges of the manufacturing engineer.

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.