Additive Manufacturing for Jigs, Fixtures and Other Factory Floor Tools

How to realize an extreme reduction in time and cost by making your custom tools via additive manufacturing

stratasys

White Paper

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The fundamental objectives of manufacturing — improve quality, reduce costs, speed up throughput and increase production flexibility — are the primary reasons that jigs and fixtures are so abundant. It doesn't matter if the operation is fully automated or entirely manual; jigs and fixtures are deployed throughout manufacturing operations with the goal of reducing costs while improving production processes.

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When expanded beyond jigs and fixtures to include all manufacturing tools that serve as operational aids, the uses are even more widespread. They range from organizational bins and tool holders for 5S (a workplace organizational methodology) to templates, guides and gauges. They include sophisticated robotic end-effectors and rudimentary trays, bins and sorters for conveyance and transportation. No matter the name, description or application, manufacturing tools on the factory floor increase operational efficiency while maintaining quality.

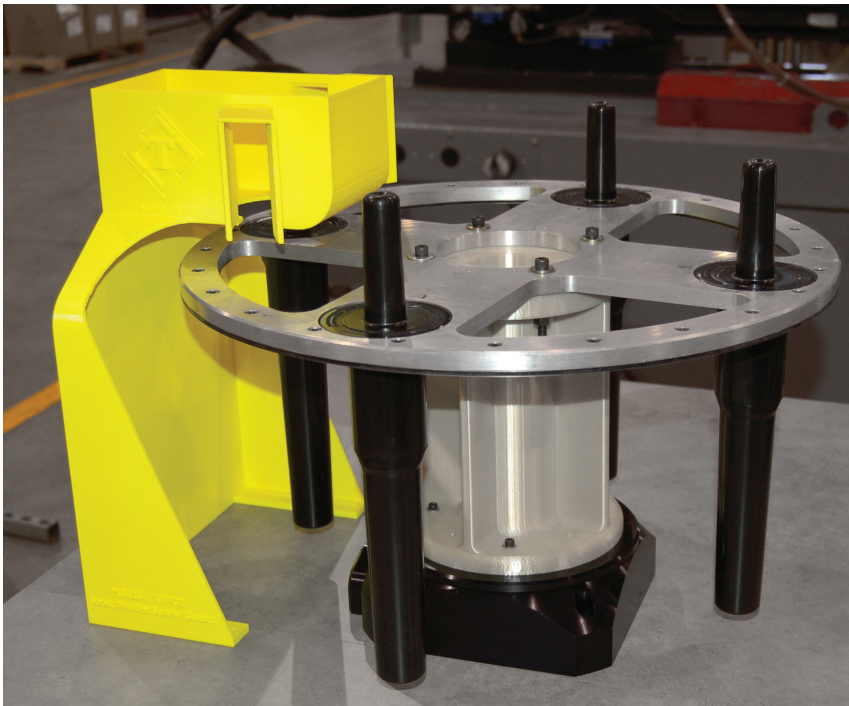
Additive manufacturing (AM) generates opportunities for tools that would not have been feasible using aluminium or another machinable polymer due to high manufacturing costs or the heavy weight of the final tool. It is simple and automated, fast and inexpensive. This allows you to deploy more jigs and fixtures while optimizing their performance for the function of the tool.

Lowering The Barrier

By supplementing your current methods of making jigs and fixtures with AM, you can reduce the cost and accelerate delivery. In these terms alone, AM systems are easily justified with short payback periods. But this ignores the larger impact on the bottom line. AM lowers the threshold for justifying a new tool, which allows you to address unmet needs throughout the production process. If you were to look around the manufacturing floor, assembly area and quality control lab, how many new opportunities would you find for a jig or fixture? What would the value be?

- Reduce scrap and rework
- Decrease direct labor time
- Improve process throughput
- Improve process control and repeatability
- Reduce strain
- Improve worker experience

And with respect to the bottom line, how much more profit would the company gain?



According to Thogus' quality control manager, it is simpler, faster and less expensive to make its own FDM fixtures than to outsource them to a machine shop.

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More importantly, why aren't jigs or fixtures currently being used in these operations if they have value? Most likely, they were not justifiable. Although there is a benefit in having the jig or fixture, the return on investment (ROI) isn't large enough to warrant the effort. You may have found that your time and money were better spent elsewhere. Since there is never enough time in the day or money in the budget to do everything you would like to do, the decision to build a manufacturing tool puts priority on the:

- Processes that aren't possible without a jig or fixture
- Most obvious and urgent needs
- Largest threats and most likely problems
- Quickest to implement and produce results
- Easiest to implement
- Safety concerns

Deciding when and where to use a jig or fixture is made when value outweighs investment or when the path has the least resistance.

AM lowers the justification threshold by increasing your ROI and decreasing the obstacles between a great idea and a solution. It does this by simplifying the process, lowering the cost and decreasing lead time.

When using fused deposition modeling (FDM®) to make jigs and fixtures, the process has just three steps: prepare the CAD file, build the tool and perform any necessary post processing. Unlike conventional fabrication methods, FDM requires little experience and minimal direct labor. In many cases, jigs and fixtures are manufactured with only 15 minutes of hands-on labor. More importantly, they are manufactured with little training on how the process works and no need for prior experience. Combined, this makes FDM an ideal "self-serve" option for jigs and fixtures. According to Natalie Williams, quality manager at Thogus Products, an injection molder that specializes in low-volume manufacturing and highly engineered materials, "It is so much easier for me to model a fixture and print it myself than it is to design it and work through an outside machine shop."

The bottom line: AM lowers the threshold so that manufacturers can put more jigs and fixtures, with optimized designs, into service.

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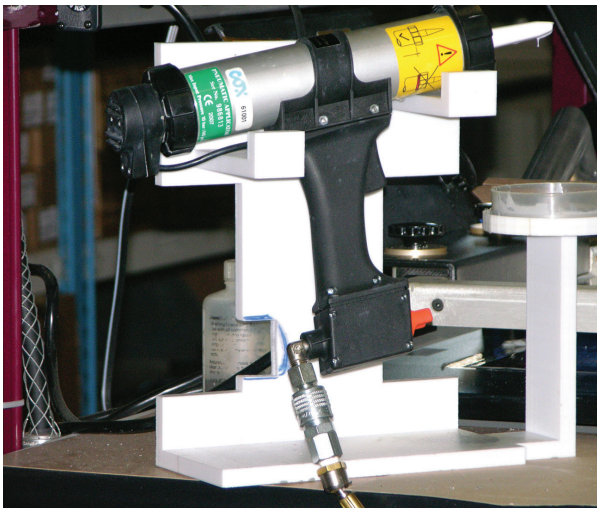
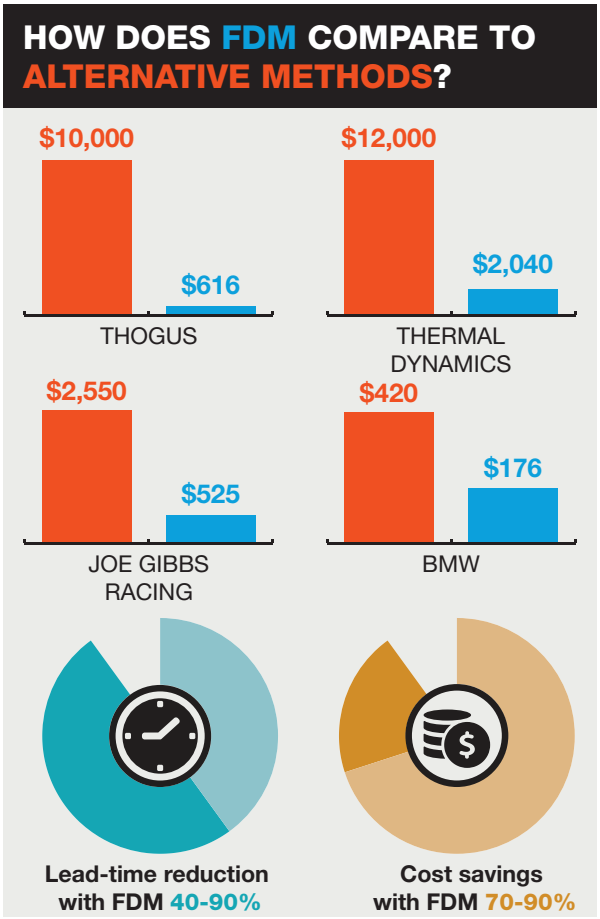


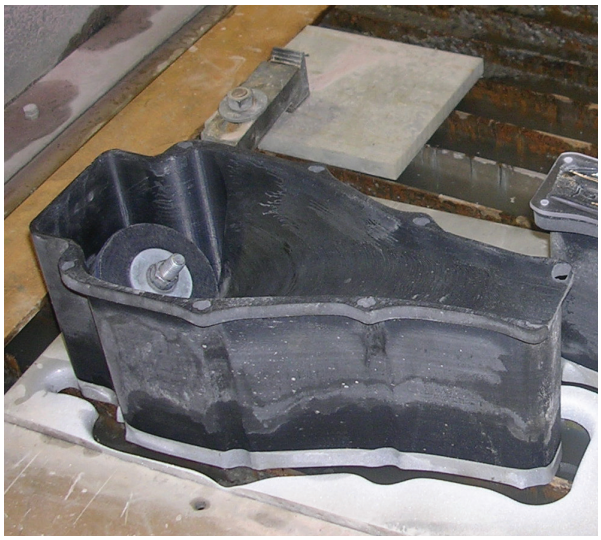
When machined fixtures were quoted at $12,000 and seven days, Thermal Dynamics opted to make them with FDM to save $10,000 and several days.



For Thogus, AM is easy and fast. “For one 12-cavity CMM fixture the lead time, if outsourced, was 7 to 10 days. I built it overnight,” Williams said. Manufacturers using FDM to create custom manufacturing tools often experience lead-time reduction from 40 to 90 percent.

AM also can increase ROI substantially by reducing the cost of a jig or fixture. Typically, companies realize savings of 70 to 90 percent when compared to outsourced fixtures that are machined or fabricated. Thogus saved 87 percent using AM to build their 12-cavity fixture. “The machine shop wanted $1,500 for the fixture. I made it for less than $200 in materials,” said Williams.

Making the tool fabrication process faster and more affordable, AM will increase the number of jigs, fixtures and other manufacturing tools, which will improve the bottom line. AM can also optimize manufacturing tool performance for operational functionality. Before AM, designs that



Top NASCAR team, Joe Gibbs Racing, uses FDM to make fixtures, some of which have been in service for more than two years and have cut lead time and expense by an average of 70 percent.

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were sufficient to do the job were acceptable for jigs and fixtures. Due to the expense and effort to redesign and re-manufacture them, revisions were reserved only for those that did not work as specified. Although “good enough” may have added a few seconds to an operation or increased the scrap rate by a small percentage, the savings might not have warranted further investment in the tool. AM changes that thinking. It can deliver the next-generation manufacturing tool and have it in service the next day. Redesigning a tool that was once “good enough” requires only a little time, and may only drive out a few seconds from an assembly operation, for example, but that time adds up. If the fixture makes 500 items per day per worker, a two-second savings reduces direct labor by 70 hours per person per year. For the same part, a one-percent reduction in scrap would save 1,250 parts per year. The bottom line: AM lowers the threshold so that manufacturers can put more jigs and fixtures, with optimized designs, into service. This drops more money to your company’s bottom line.

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By using additive manufacturing to recreate a gripper with internal vacuum channels, Digital Mechanics eliminated five external hoses that hampered operations.

Implementing An Additive Approach

Before creating your first 3D CAD model and uploading it to an FDM system, take materials and dimensional tolerance into account. While AM is ideal for many manufacturing tools, it isn't right for all of them. The main consideration for materials is whether plastic will suffice. Traditionally, jigs and fixtures have been fabricated in metal. For some, metal may be a practical option because of the low cost and because it is conducive to milling, turning, bending and fabricating. In this case, AM may be an option. The range of FDM materials can offer chemical resistance (petroleum, solvents), thermal resistance (up to 390 °F/ 200 °C) and resilient mechanical properties.

Machining traditional materials follows a well established methodology around the implementation of jigs, fixtures and other factory floor tools. AM allows the consolidation of some of these processes and can reduce the timing of deployment and in often cases reducing cost.

Plastic manufacturing tools may also deliver some unexpected advantages. For example, Thogus uses FDM-made robotic attachments that absorb impact. In the event that the robot arm crashes into an obstacle, the FDM part is likely to isolate the arm from damages, which prevents expensive repairs and downtime. In another example, BMW uses plastic, hand-held tools because they are lighter and easier to handle, reducing worker fatigue.

When deciding whether to try AM on some initial toolmaking projects, for dimensional accuracy, pick tools requiring tolerances larger than 0.010 inch (0.254 mm). Tighter tolerances are possible, but as a rule, stick with this value when keeping the process simple.

Using FDM, BMW prints jigs and fixtures that would not be possible with conventional machining and fabrication.

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Using FDM, BMW prints jigs and fixtures that would not be possible with conventional machining and fabrication. AM allows them to be easier to use and more functional.

This ergonomic and lighter BMW hand tool reduced worker fatigue.

Design

Your current jigs and fixtures were designed with consideration for the capabilities and limitations of the fabrication methods used to create them. By adhering to design for manufacturability (DFM) rules, you made them practical, kept cost to a minimum, and made lead times reasonable. These rules don't apply the same way to AM. The additive nature of the process gives you unmatched freedom of design. What may have been impractical is now realistic and reasonable. Jigs and fixtures can have complex, feature-laden and freeform configurations. In fact, added complexity may even reduce cost and time. For example, pockets, holes and channels reduce material consumption, build time and total process time. To leverage AM, let the function and performance of the jig or fixture dictate the design. Follow the lead of companies like Digital Mechanics AB and BMW. Digital Mechanics capitalized on the freedom of design for a vacuum-assisted robotic gripper. Conventionally made, the gripper had external hoses hanging off it. With AM, each finger of the gripper was given an internal vacuum channel that eliminated the hoses. For BMW, freedom of design allows assembly line workers to have a tool that reaches under, behind and inside the rear of the bumper. Manufacturing engineers focused solely on the function, which resulted in an organically shaped bumper-reach tool. Design freedoms can also improve the ergonomics of manufacturing tools. The weight, balance and position of the tool have direct effects on technician comfort, process cycle time and ease of access and storage. To achieve optimal ergonomics, simply design it into your tools. For example, BMW redesigned a badge alignment fixture to improve balance and reduce weight. This reduced worker strain and improved the cycle time for badge attachment.

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One very simple way to leverage the freedom of design is to consolidate assemblies into single parts. Often, jigs and fixtures are composed of many pieces due to geometric complexity.

This is unnecessary with AM. If reproducing an existing tool, start with a redesign that consolidates as many components as possible into one piece. If designing a new item, create it as one piece. Only split off parts when it is required for the operation of the jig or fixture, such as an adjustment requirement. Integrating parts into a single component has many advantages:

- Eliminate tolerance challenges. Holding tight tolerances is costly. If two mating parts are combined into one, then all costs and concerns about controlling the tolerances of the mating parts are eliminated.
- Eliminate assembly time. Assemblies, obviously, must be assembled. This takes time, especially for one-off items like jigs and fixtures, where perfect fits are not guaranteed.
- Minimize documentation and overhead. The sum of the parts is less than the whole when it comes to time and cost. Consolidating parts reduces costs for actions such as design, documentation, quoting, ordering and inventory management.

Management

No longer consider your jigs, fixtures and other manufacturing tools as assets. Instead, think of them as expenses, and disposable. As assets, jigs and fixtures are stored (inventoried) between uses. They remain in inventory until the product line is retired or they are worn beyond repair. Manufacturing tools made through conventional methods, however, are too valuable to be discarded as a disposable, expensable item due to the time, cost and effort required to create them. This approach carries many indirect costs, however. There is cost for the shelf space (warehousing expense); cost to manage and track the inventory; and cost to locate a jig or fixture when needed. For sporadically used tools, these costs can be quite significant.

The opposite can be true with AM. Often, it takes more to inventory the jigs and fixtures than it does to re-make them. So, companies adopt a management approach called digital warehousing where only the digital file is carried in inventory. It may seem unthinkable to scrap a perfectly good manufacturing tool, but for those with infrequent use, this approach reduces cost and labor.

Make a fixture when it's needed. When its job is done, send it off with the scrap material for recycling. Then digitally warehouse its design between uses. This print-on-demand approach is also handy when a replacement is needed for a broken manufacturing tool or duplicates are needed for increased production to meet an unexpected surge in sales.

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Conclusion

AM can lead to big changes that maximize profits by driving out every wasted second and penny from the manufacturing process. For those who aren't ready to toss out long-established design guidelines, simply replace the usual fabrication processes with AM. Either way, the savings on the manufacturing floor and in jig and fixture production will be substantial.

If you have a 3D CAD drawing and access to a AM, you are ready to start making manufacturing tools with as little as 15 minutes of hands-on labor. Combine the simplicity with typical time and cost reductions of 40 to 90 percent, and you will understand why AM spurs companies to make more jigs, fixtures and other manufacturing tools than ever before.

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