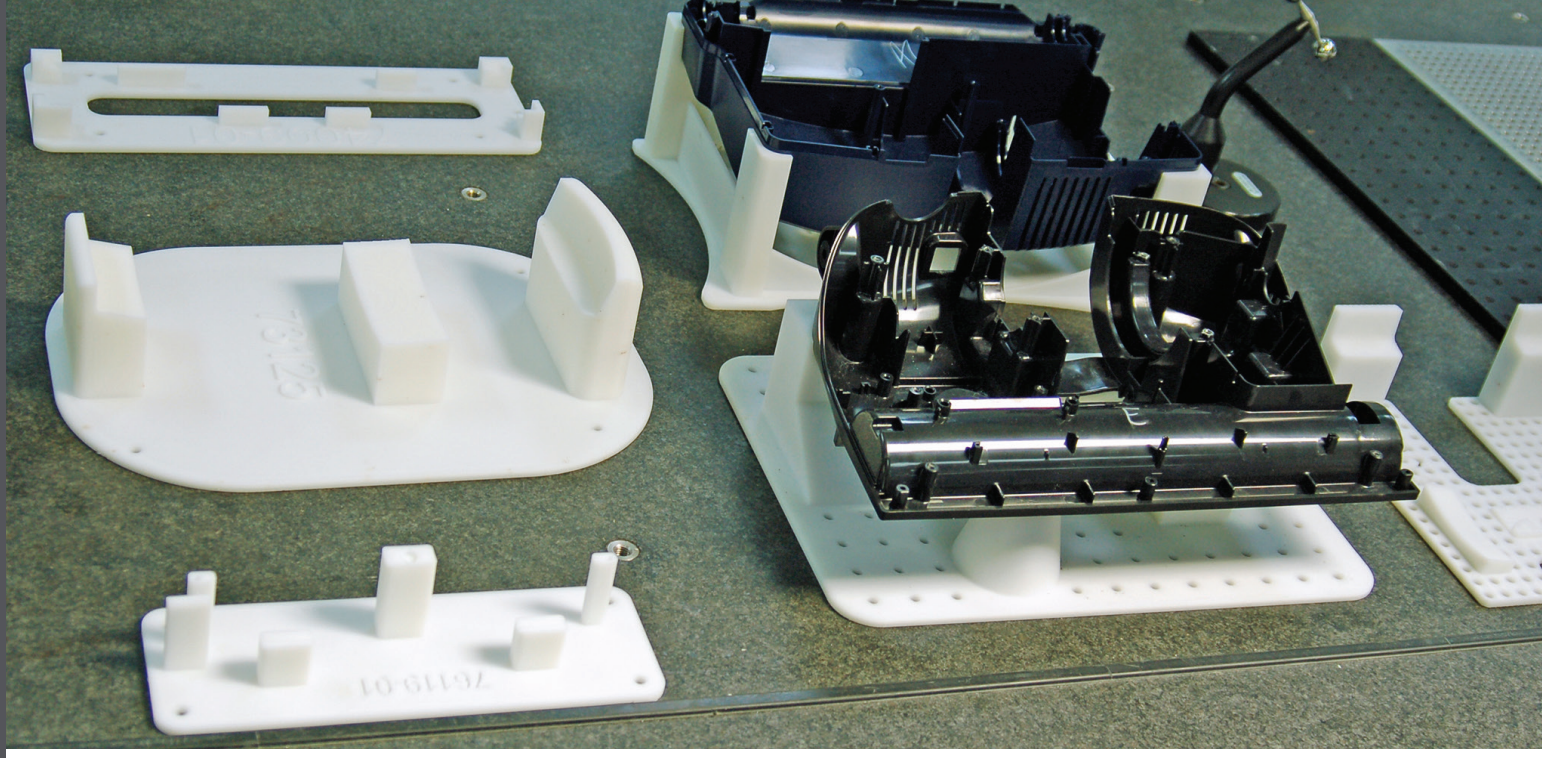

3D Printed Jigs and Fixtures for the Factory Floor

The Challenge

Here are your marching orders: produce more, increase quality, lower work-related injuries and reduce costs. If you're a manufacturing engineering or production manager, this should sound familiar. But is this really achievable, particularly when resources are always tight?

We're here to say it *is* possible. But it requires following a particular strategy, one that challenges the status quo. It involves changing the way you think about the tooling your organization uses to keep the factory floor running, so you can make your operation more efficient, safe and cost-effective.

All manufacturing operations use jigs, fixtures and other tools to make products. They're an indispensable part of the production process. The problem is that most manufacturers rely on conventional tooling, usually comprised of machined metal parts that are bolted or welded together. Although they've served admirably since the beginning of the industrial age, there's a better way to do things.

Before we get into that, let's look at the current mindset around production tooling.

The tools on your production floor are probably limited to a minimum amount sufficient to achieve a certain production rate and level of quality. They're limited because for starters, they're expensive to make. Machined tools rely on skilled machinists and their designs are limited by typical manufacturing constraints. A lot of material typically goes to waste in the subtractive machining process.

Solution Guide

3D Printed Jigs and Fixtures for the Factory Floor

Tools made using traditional methods like CNC machining, welding and assembly also take a long time to fabricate. If they're outsourced, the vendor's backlog, turn time and shipping adds to the lead time. Similar constraints exist for in-house production. In addition, locally made tools consume resources that could be used for revenue-generating production. But even if your internal machine shop doesn't work on your end products, why tie up skilled machinists for simpler, low-requirement tools that can be 3D printed instead?

Metal tools can be heavy and larger ones aren't easy to manipulate. They can cause worker strain and injury. If they require accessory tools like overhead cranes and hoists to move about, it slows down the task. Often, these tools are designed only for the job, not with the user in mind. This contributes to fatigue and repetitive motion injuries as workers accommodate the tool instead of the other way around.

This tooling paradigm has been and continues to be the norm for most manufacturing operations. But it extracts a penalty in the form of limiting a manufacturer's capabilities to improve operations. That might sound counterintuitive because tools help facilitate production. But not when they're too expensive, hard to justify and too limited to change the current situation. Most operations simply make do and assume the status quo is a cost of doing business.

3D printed tools can replace typical metal, multi-part, welded assembly jigs like this.

3D Printed Jigs and Fixtures for the Factory Floor

The Solution

Making tools using 3D printing, also known as additive manufacturing (AM), instead of conventional means, is a key component to improving your factory floor operation. AM tools help increase production, elevate quality, lower cost and reduce worker injuries. They benefit virtually all areas of the manufacturing process including production and assembly, quality control and inspection, health and safety, and packaging and logistics.

This 3D printed assembly tool provides a lighter, faster means of installing wheel lug nuts.

Relative to cost, AM tools are typically less expensive to make. After the cost of the printer, only the amount of material needed to build the tool is required. Contrast this with subtractive machining, where most of the material ends up as chips on the machine shop floor. 3D printers don't require a dedicated or highly skilled operator either, unlike a CNC milling machine. Once the 3D printer starts printing, it's on its own until the part is finished.

Reduction in lead time is another key benefit. 3D printed tools can be manufactured much more quickly than conventionally made tools. 3D printing avoids typical delays associated with outsourcing or a backlogged internal machine shop. Adopters of AM tooling have experienced turn time savings of 80 to 90 percent compared to the conventional tool-making process. This is particularly significant when a tool breaks, halting production or when you need to tool up a new production line. Being able to 3D print tools overnight instead of waiting three weeks to fabricate a machined or welded tool significantly minimizes production downtime.

3D printing lets you iterate your tool design much more efficiently. Print the tool, try it and if changes are needed, revise the CAD design and print another one. This allows you to optimize and achieve the best tool design. In most cases, this wouldn't be possible with machined tools due to the time and cost involved.

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Design freedom offers additional benefit because it avoids typical manufacturing constraints. With a 3D printed tool, you can vary the material density, using more at key stress points and less in non-stressed locations. And this variability is handled automatically by the printer in one print operation. The result is a lighter tool that's easier to use. Achieving the same goal with a metal tool is difficult, if not impossible. This capability also lets you create tools that are more ergonomic, making tasks easier and more efficient.

The combination of these benefits – lower cost, faster creation, better design – makes it possible to create and deploy more tools in the production process. Faster production cuts the time needed to tool up a new production line. Tools that could make tasks more efficient and precise but couldn't previously be justified due to time and/or cost, now can be. New tools that make tasks easier to accomplish increase task efficiency. More fit-check tools on the assembly line ensure any quality escapes are noticed and addressed earlier. The result is a compounding effect of reduced cost and increased efficiency throughout the production process.

This single-piece inspection tool (white) replaces what would normally be a multi-piece welded assembly.

3D Printed Jigs and Fixtures for the Factory Floor

Putting Them to Work

Production and Assembly Tools

Production and assembly tooling offer one of the largest opportunities for harvesting the benefits that AM tools offer, primarily because of their prevalence in the manufacturing process. Opportunities for new or replacement AM tools include:

- Assembly fixtures
- Alignment tools
- Holding devices
- Milling fixtures
- Drill and cutting guides
- Robot end effectors
- Check/fit tools
- Surrogate parts
- Paint masks

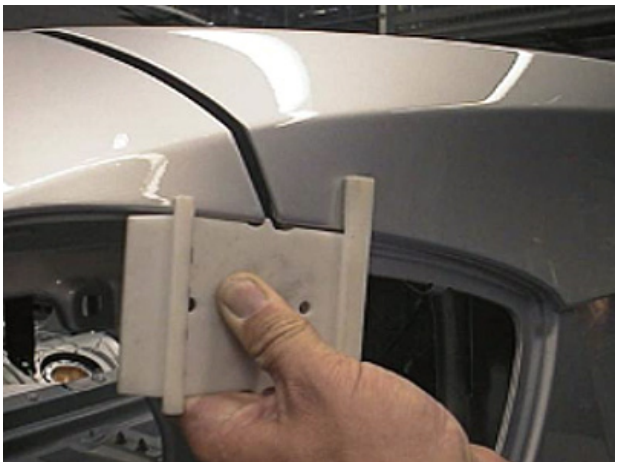
A good start is looking at your existing tool inventory to determine where you can supplement with AM jigs and fixtures. From there, use AM tools as replacements when existing ones break, go missing or wear out.

Robotic end-of-arm tools (EOATs) are a good example where AM's lightweight strength and design freedom make conventional units obsolete. A lighter EOAT makes it possible to use smaller robot actuator motors or increase the arm's actuation velocity. 3D printed EOATs can also consolidate multi-part designs and incorporate internal vacuum channels and other integral features.

Easily fabricated drill fixtures speed the assembly process on this space launch vehicle.

Lighter 3D printed end-of-arm tools reduce the load on robotic arms and are typically faster and less costly to make than their metal counterparts.

3D Printed Jigs and Fixtures for the Factory Floor



A worker inspects the fit on this auto assembly using a 3D printed check gauge.

This CMM inspection fixture was created in a fraction of the time it would take to manufacture metal tooling.

Quality Control and Inspection

Quality control also offers fertile ground for implementing AM tooling. In addition to the inspection department, applications involve many touch points throughout the manufacturing cycle where quality can be assessed and controlled. Typical opportunities include:

- CMM fixtures
- Test fixtures
- Go-no-go gauges
- Surrogate parts
- Fit check gauges
- Work holding devices

An example where AM inspection tooling can be “doubled up” is with CMM fixtures and surrogate parts. First-article inspections on new products usually require setup of inspection fixtures to determine that the parts meet specs. But until the first article is produced, validation of the inspection program has to wait, adding delays. Instead of waiting, an accurate first article can be 3D printed and used to verify the CMM programming. It’s just one example of how you can leverage additive manufacturing in multiple ways to save time and expedite production.

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Packaging and Logistics

The benefits of AM also extend to packaging, logistics and part handling. Don't overlook these areas because effective organization and protection of goods throughout the manufacturing process offer tangible benefits. Opportunities here involve:

- Tool guards
- Dunnage trays
- Kitting boxes
- Thermoforming molds

The design freedom of additive manufacturing makes it easy to create custom tool holders and sorting trays.

Additive manufacturing's design freedom lets you easily create tool holders and dunnage trays that conform to the tools and parts they contain. That includes complex shapes too, since AM isn't constrained by typical subtractive machining limitations.

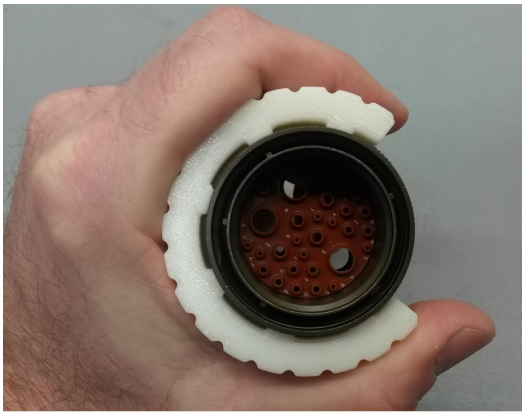
FDM technology also offers a fast and inexpensive way to create thermoforming tools that can be used to create multiple bins, conformal trays and packaging material. This avoids the time and cost you'd typically incur with a machined metal thermoform tool.

Health and Safety

How AM tooling benefits occupational safety may not seem readily apparent. It's assumed that any company-sanctioned tool is safe and doesn't injure the user. But this mindset overlooks the long-term implications of repetitive use, not to mention the reality that most things, tools included, can be improved on.

The white 3D printed thumb tool provides leverage to reduce fatigue and prevent overuse injury when inserting these plastic plugs.

3D Printed Jigs and Fixtures for the Factory Floor



This 3D printed gripper gives workers a more comfortable way to grip the connector, reducing fatigue.

Typical opportunities include:

- Hand and wrist guards
- Holding devices
- Bumpers and guards
- Ergonomic conversions

AM's fast, affordable and customizable characteristics make this category an easy win for tools that improve worker safety, without significant investment. Because AM tools can be created quickly, simple ideas for improving a task's safety can be usually be put in service the next day.

Additional opportunities involve replacing heavy, cumbersome tooling with lighter, more ergonomic 3D printed tools. Repetitive motion injuries can be reduced by lowering a tool's weight and redesigning it so it's more comfortable for the worker. A corollary benefit is an increase in task efficiency and the compound effect of cycle time reduction as the repetitive time savings add up.

This is one area that shouldn't be ignored. The U.S. Occupational Safety and Health Administration estimates injuries cost employers close to $1 billion per week in direct worker compensation.[1] Repetitive strain injuries build over time and progressively impact your workers, reducing their effectiveness and productivity until they need to be relieved. Lighter, more ergonomic 3D printed tools can help reduce or eliminate lost time injuries due to this type of repetitive strain, minimizing the impact on production and benefitting your workers.

3D printing this automotive door seal jig resulted in an 80% weight reduction and a decrease in task cycle time.

[1] https://www.osha.gov/dcsp/products/topics/businesscase/costs.html

3D Printed Jigs and Fixtures for the Factory Floor

Material Diversity is the Key

A common question regarding AM tools is whether they're strong and durable enough to replace metal. The truth is, in many cases, metal isn't required. That's why we recommend FDM® 3D printing technology. The beauty of FDM technology is its diverse material portfolio. It includes engineering-grade thermoplastics and high-performance polymers, each with different performance characteristics.

ABS and ASA are perfect for many tooling applications, where high loading is not a factor. FDM® TPU 92A is an elastomer that's a perfect choice for flexible, conformal paint masks. For more demanding applications, materials like FDM Nylon 12CF™ (carbon fiber), ULTEM™ PEI resins and Antero™ PEKK-based materials offer high-performance, chemical-resistant and high-strength characteristics.

One material specifically designed with tooling in mind is Diran™ 410MF07. It's a nylon-based polymer distinguished by a tough but smooth, slippery surface finish. This low-friction feature makes it a good choice for applications requiring sliding surfaces between tools and parts.

There will always be some applications that demand the use of metal. But many, arguably most, jigs, fixtures and assembly aids can be 3D printed with FDM thermoplastics.

A soft-touch, flexible assembly tool made from TPU 92A elastomer locates a badge on the motorcycle tank without marring the painted surface.

3D Printed Jigs and Fixtures for the Factory Floor

Take the Next Step

Whether you see it yet or not, there is plenty of opportunity to improve your factory floor operation with AM jigs, fixtures and manufacturing aids. The Stratasys sales and support team routinely performs factory-floor walk-throughs to help customers identify areas where AM tooling can help. Inevitably, opportunities are found. And in a matter of a day, perhaps less, an idea that makes a task more efficient, safer, less costly or all of the above, goes from CAD model to a working tool.

3D printing has multiple uses that include prototyping and production parts. But jigs and fixtures are low-hanging fruit for improving your manufacturing operation. It's an opportunity waiting to be seized.

To learn more about the materials and printers available to support the creation of AM tooling, visit the Stratasys Jigs and Fixtures web page.

If you have questions and are looking for answers beyond the scope of this solution guide, ask one of our experts.

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