RAISE3D

Boosting Manufacturing Flexibility with 3D Printed Jigs and Fixtures

White Paper

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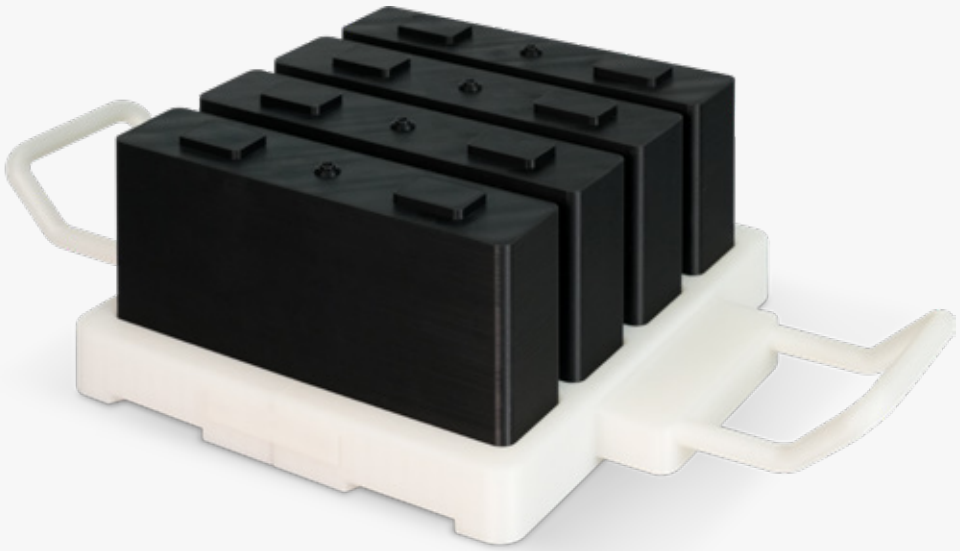
1 Introduction

- The COVID-19 pandemic has caused significant disruptions to manufacturing across the globe. As a result, businesses have realized the importance of taking advantage of innovative technology to remain agile and flexible in their manufacturing processes. Companies that had already integrated 3D printing into their manufacturing operations prior to the pandemic were better equipped to navigate the uncertain times that lay ahead. For businesses that are unsure about the advantages that 3D printing can offer in the manufacturing process, a clear example can be seen in the production of jigs and fixtures. The use of 3D-printed jigs and fixtures in the production line can reduce lead times, increase design freedom, and lower costs for low-volume production.



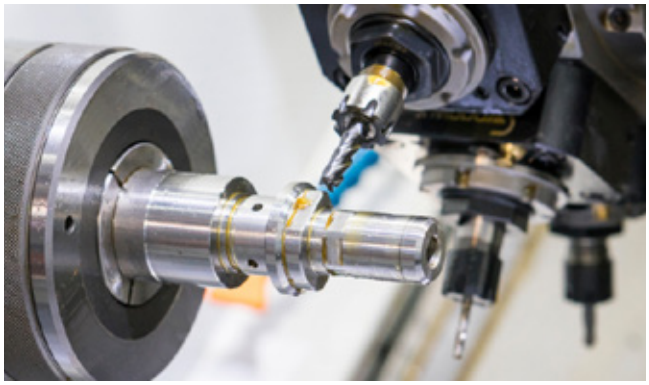
2 Jigs and Fixtures Are Widely Used in Manufacturing Lines

- In a manufacturing facility, jigs and fixtures are essential components in mass assembly and production lines, where large quantities of identical parts need to be produced quickly and accurately.

- A jig is an apparatus used to hold the position of a tool or to guide a tool to perform a specific manufacturing task. They enable precise positioning and alignment of parts, helping to eliminate errors, ensure accuracy, and achieve reliable repeatability. Fixtures, on the other hand, securely hold a workpiece in a specific position, orientation, or location. By combining jigs and fixtures, manufacturers can achieve the precision required for their products to be accurately made and to function properly.

- Jigs and fixtures must be durable and able to withstand the rigorous manufacturing processes involved in producing hundreds or thousands of parts. Some are even required to handle high temperatures and extreme forces. Additionally, the designs must allow for easy and quick changeovers between different products to maximize efficiency.

Source: https://blog.metcar.com/how-gas-turbines-in-jet-engines-use-air-bleed-valves



Source: https://dynamicdiesupply.com/types-of-metal-fabrication-processes-3/

- For instance, drilling jigs typically use rigid and durable materials to withstand the forces generated during drilling. The jig's design must also be compatible with the drill press or equipment and should take into account factors such as drill bit size, chuck size, and shank type. Welding jigs, turning jigs and assembly clamps, jaws, and chucks may also have specific requirements unique to their respective manufacturing processes.

3 How Are Jigs and Fixtures Traditionally Made?

- Jigs and fixtures are typically made using various manufacturing processes, depending on factors such as the desired specifications, material, and complexity. Common techniques used in their production include CNC machining, welding, and casting.

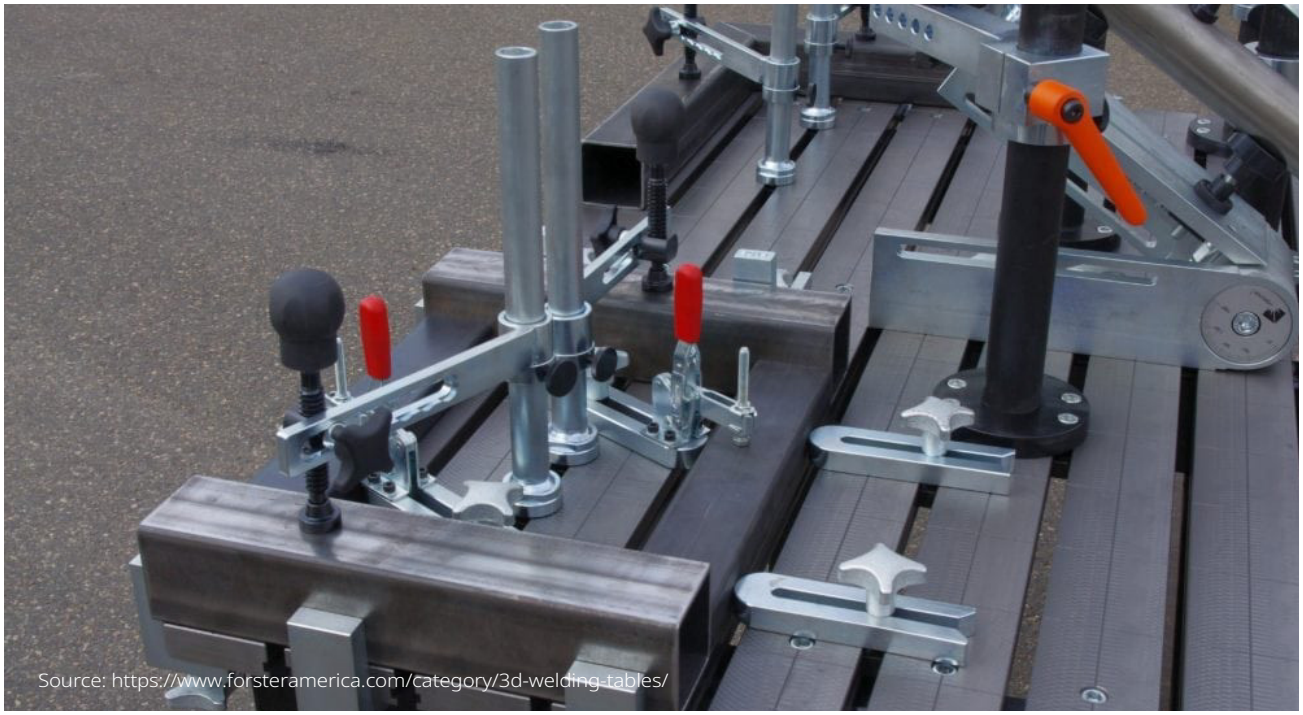
- CNC machining is the most commonly used method for producing jigs and fixtures. This process involves using computer programs to control the movement of cutting tools, resulting in very precise cuts in a range of materials. However, CNC machining can be a slow process, especially for complex parts that require multiple operations. Additionally, producing complicated designs can be challenging with only 3- or 5-axes machines.

- While CNC machines can be expensive to purchase and set up, they are worth the investment for large-scale manufacturing operations that require precision and accuracy. However, for small-scale operations, the cost of purchasing and operating CNC machines, as well as hiring skilled operators, may be prohibitively high.

Source: http://t-artisan.com/aluminum-cnc-machining/

- Welding is a common method used to join different components of jigs and fixtures together, such as plates or brackets. Welding can create a strong and durable joint, but it requires skilled operators to ensure high quality and strength. It is important to control how the weld is applied, as excessive heat in a localized area during the welding process can cause distortion and warping of the parts.

- Casting is a manufacturing process that involves pouring liquid material into a mold to create a solid part. While casting can produce parts with less precision compared to other processes, it can be a suitable option for larger jigs and fixtures with complex shapes and features. However, it may not be the best choice for parts requiring high accuracy.

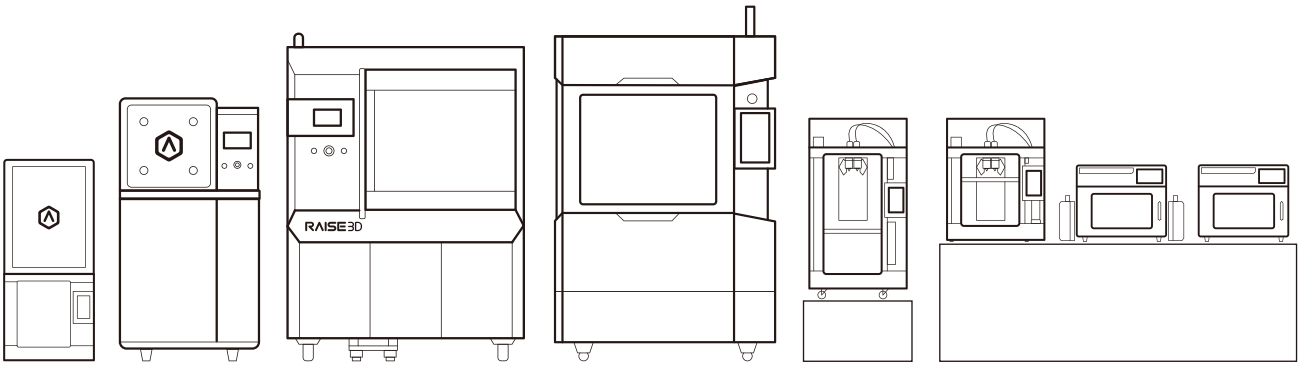

Source: https://www.forsteramerica.com/category/3d-welding-tables/

- Smaller manufacturing operations often outsource the production of jigs and fixtures to machine shops or service bureaus, which usually mean longer lead times and higher costs. Shipping heavy jigs and fixtures can add to the expense. During the pandemic, the supply chain shortages created delays for manufacturing operations that rely on overseas machine shops for producing jigs and fixtures. Additionally, inflation has led to an increase in the costs for outsourcing these parts.

4 What Are the Benefits to 3D Printing Jigs and Fixtures Tools In-house?

- The use of 3D printing for producing tools has garnered more and more interest, particularly after many people experienced supply chain delays during the pandemic. Having a 3D printer in-house allows for rapid iterations and consequent design changes, as manufacturing engineers can quickly design, test, and refine whatever they wish to produce without causing great delays in the manufacturing schedule.

- For small-batch or custom production runs, the benefits of in-house 3D printing become even more prominent. This method can often be a better alternative to other manufacturing methods when the 3D printed parts meet the mechanical and accuracy requirements, and the project schedule and agility are critical. Jigs and fixtures can be printed as needed in smaller quantities, which is still cost-effective and yet allows for the full customization of specific project needs, resulting in higher quality and consistent end products.

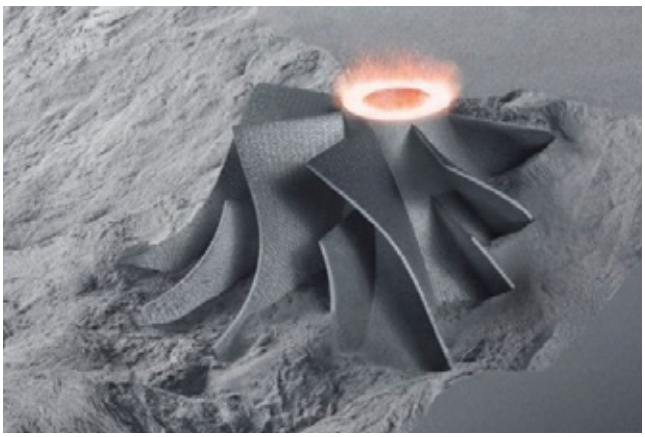


- Having an in-house 3D printing shop can also reduce unplanned manufacturing downtime, a possibly costly occurrence that can have a negative impact on the business's bottom line. When unplanned downtime occurs, not only is the time and resources invested in preparing for and setting up the product line wasted, but resuming normal operations can be difficult. Waiting on replacement tools can take weeks and having an in-house 3D printing shop can be crucial to get you back into production as soon as possible. The lifespan of 3D printed jigs may not be as long as those made via CNC machining with aluminum, however, it can serve as an effective temporary solution during the waiting period for replacement parts, preventing any delays that may escalate into bigger issues.

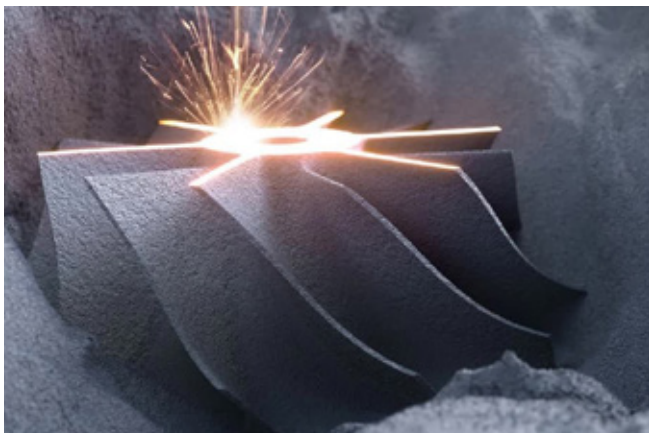
- One of the advantages of 3D printing is the freedom it provides in designing complex shapes and geometries that might not be possible or practical with traditional manufacturing methods. Additionally, 3D printing allows for easy consolidation of multiple parts into a single component, reducing the need for assembly and potentially lowering labor costs. However, it's important to note that the mechanical properties of the 3D printed parts should meet the requirements for the specific application, especially if the part will be used in a high-stress or high-temperature environment.

5 Commonly Used 3D Printing Technologies for Rapid Jigs and Fixtures Production

- There are several 3D printing technologies that are commonly used for making jigs and fixtures, including Fused Filament Fabrication (FFF), Stereolithography (SLA), Selective Laser Sintering (SLS), Digital Light Processing (DLP) and Binder Jetting.



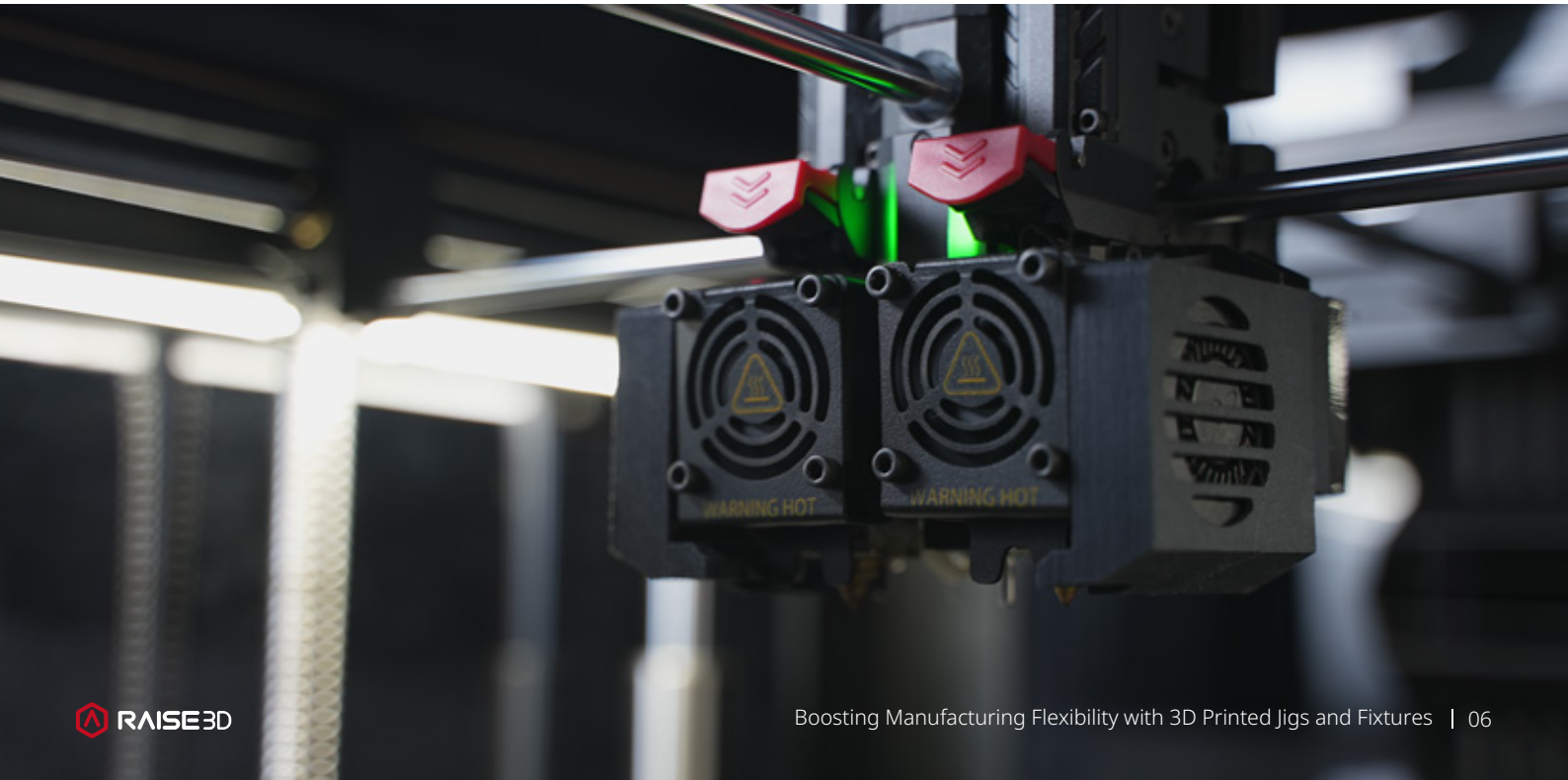
Source: https://www.trumpf.com/en_IN/solutions/applications/additive-manufacturing/laser-metal-deposition/



Source: https://www.3dnatives.com/en/direct-metal-laser-sintering100420174-2/

- SLA and DLP 3D printing technologies offer the advantage of producing highly detailed and precise parts with a smooth surface finish and good dimensional accuracy. Additionally, a variety of resins with different properties such as rigidity, flexibility, transparency, and toughness are available for selection. However, DLP typically has a significantly smaller build volume than other 3D printing technologies, which may not be suitable for larger jigs and fixtures. Moreover, post-processing steps such as washing, curing, and sanding are required for SLA and DLP parts, which can add to the production time and cost. Lastly, the mechanical properties, durability, and long-term stability of the parts may give rise to limitations to possible uses.

- SLS produces durable and heat-resistant parts, making it a suitable option for jigs and fixtures that are exposed to harsh environments or high temperatures. The high strength and stiffness of SLS parts can withstand heavy loads or repeated use. However, SLS parts tend to have a rougher surface finish compared to other 3D printing technologies, which may require additional post-processing steps such as sanding or polishing to achieve a smooth surface. Additionally, SLS parts may experience some shrinkage or warping during the printing process, which can affect the dimensional accuracy of the parts. Finally, SLS printers can be expensive, and their operation generally requires skilled technicians.



- FFF is the one of the most cost-effective ways to produce tools. It's relatively inexpensive, whether considering the cost of either printers and the filaments. The printed parts have high strength and durability when using thermoplastics like ABS, Nylon, and Polycarbonate. FFF printers come in different sizes, and offer considerably larger build volumes compared to other technologies. They are also easy to operate with a short learning curve. The process is very clean and normally doesn't need post-processing, which makes it a perfect fit for an office environment and manufacturing floor.

- Raise3D's Hyper FFF™ technology, such as the Pro3 Series, is an example of highly productive FFF printers. The Pro3 Series is capable of print speeds ranging from 200-350 mm/s and acceleration of 10,000 mm/s². This high printing speed is achieved through its active vibration cancellation algorithm and auto frequency calibration features, which allow for much faster printing compared to other FFF printers. In addition, the Pro3 Series is highly reliable for long hours of printing with minimal maintenance, reducing overall costs. It also offers high resolution and accuracy, while Raise3D's Open Filament Program (OFP) provides a wide variety of filament options, making it an ideal choice for the printing of jigs and fixtures in an environment requiring high productivity.

6 Cost Comparison Between FFF 3D Printing and Outsourcing CNC

- To better understand the cost benefits of FFF 3D printing, let us look at the specific example of an angled ball joint. In situations where only a small quantity of angled ball joints is required, a facility would typically opt to use CNC machining and a lathe to produce the pieces. Watch this video for further information regarding the benefits of 3D printing in-house versus traditional manufacturing methods, including CNC.

- The ball joint can be partially machined using CNC, and a lathe can be used to complete the finishing. A facility would require several jigs to produce an angled ball joint including: a CNC jig (also known as a clamp jig), a lathe jig (also known as a rotary jig), and a 4-hole jig.

- To compare the cost and lead times of producing an angled ball joint with 3D printing and CNC, we focused on the specific example of a couple of different types of jigs. For CNC, two service bureaus were reached out to obtain quotes for ABS and Aluminum. The price range indicated the differences between the different shops. For the 3D printed parts, a Raise3D Pro3 dual extruder printer enhanced with Hyper FFF™ was chosen to measure the necessary printing time. ABS and Nylon filaments printed with 100% infill were used for the material costs, without including the labor needed to print those parts, as this is very low. However, a total of one hour labor time can be added into the final cost for the purposes of this comparison.

Cost Comparison Between In-house 3D Printing and Outsourcing CNC

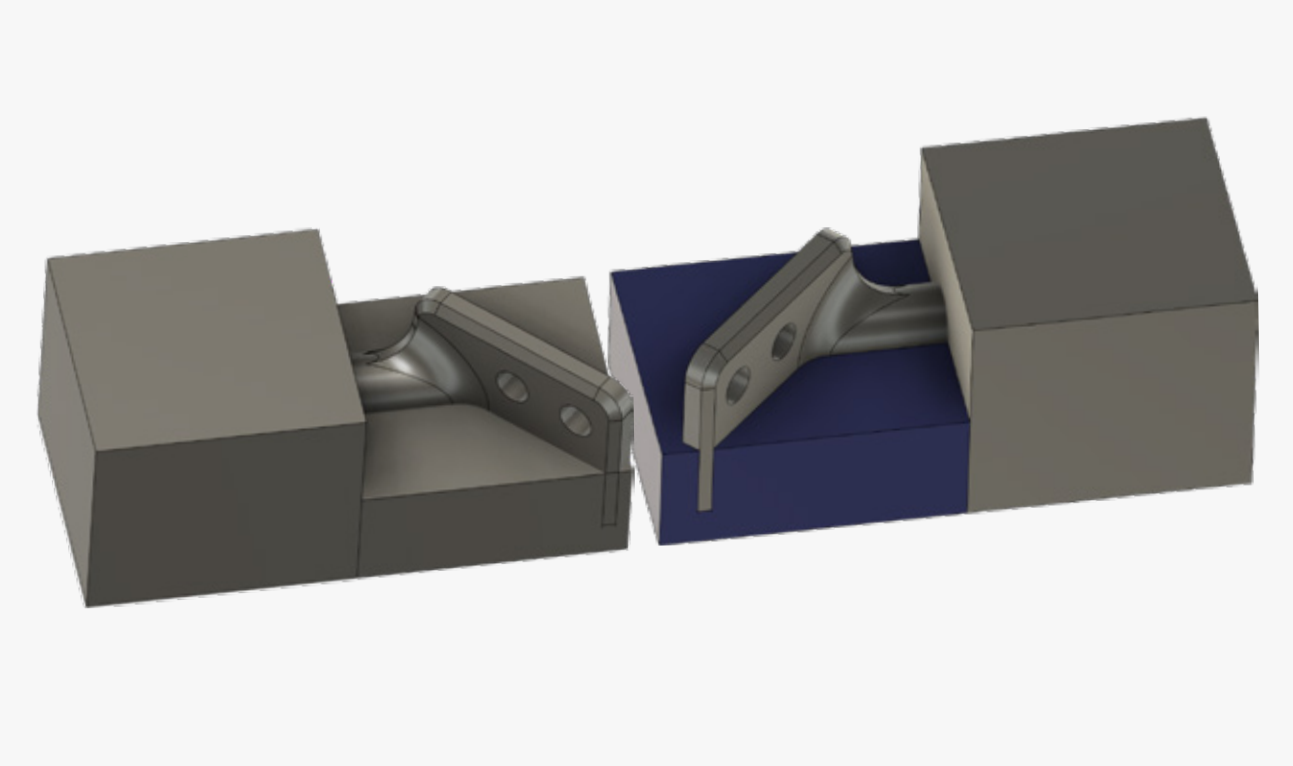
	Clamp Jig	Rotary Jig	4 Hole Jig
Quantities	20	20	20
Total cost using Raise3D printer with ABS	$5	$34	$2.5
Total cost using Raise3D printer with CF Nylon	$30	$125	$15
Total cost using CNC in ABS	$340 - $873	$500 - $774	$283 - $770
Total cost using CNC in Aluminum	$545 - $650	$430 - $1,500	$452 - $580

- As we can see from the table above, 3D printing in-house the same quantity of the same part at 100% infill is a fraction of what the cost would be in CNC. This enables businesses to remain cost-effective while producing small quantities of needed parts on demand, giving businesses the flexibility to respond to any changes in circumstance.

Lead Time Comparison Between In-house 3D Printing and Outsourcing CNC

	Clamp Jig	Rotary Jig	4 Hole Jig
Quantities	20	20	20
Total time using Raise3D printer with ABS	5 hours	19 hours	2 hours
Total time using Raise3D printer with CF Nylon	9 hours	35 hours	4 hours
Total time using CNC in ABS	13 - 19 business days	14 - 20 business days	15 - 20 business days
Total time using CNC in Aluminum	8 - 15 business days	8 - 15 business days	8 - 15 business days

- The table above illustrates the difference in lead times between 3D printing parts and CNC machining these different jigs. 3D printing jigs in-house results in a final part within hours rather than waiting 1-3 weeks for production and delivery. This gives businesses the ability to respond to situations faster, ultimately giving them more agility.



7 Applications of FFF 3D-Printed Jigs and Fixtures

Application | **Jigs for laser engraving**

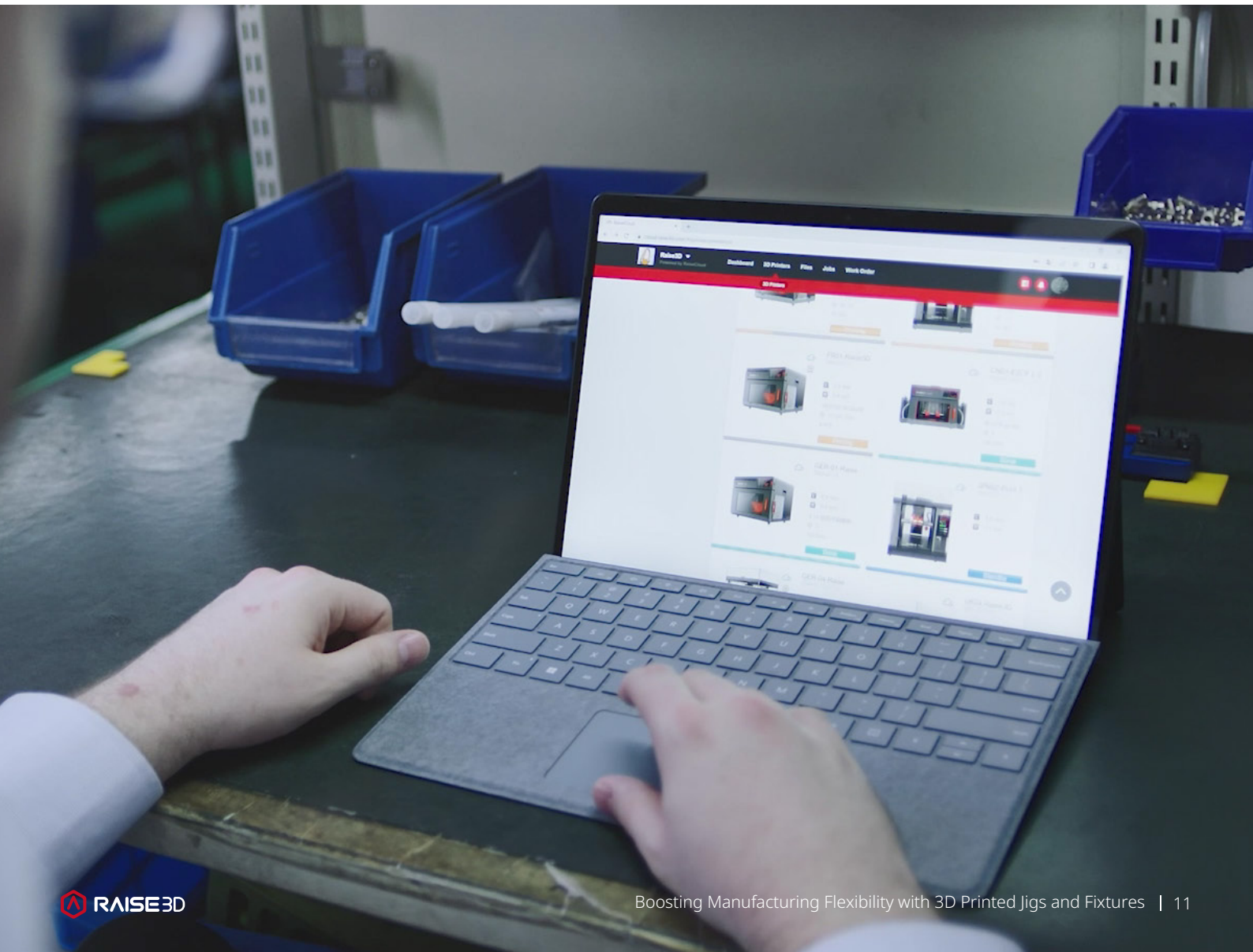
- On electric vehicle (EV) battery assembly lines, jigs are used to align and hold battery cells, battery trays, and other components in place during the assembly process. These jigs help ensure proper positioning and aid in the insertion and tightening of fasteners. Traditionally, the cost of such fixtures can be expensive using traditional machining methods. However, for low-volume production, Fused Filament Fabrication (FFF) 3D printing is a cost-effective alternative for printing relatively large-sized assembly jigs with high-strength filaments.

- A plug gauge is a tool commonly used to verify whether a part meets specific dimensional requirements. In the automotive industry, plug gauges are used to measure the diameter of engine cylinders or spark plug holes. It works by utilizing a "go" end, which represents the desired size of the hole, and a "no-go" end, which is slightly larger than the desired size. By inserting the "go" end into the hole, and the "no-go" end not fitting, it can be determined whether the hole is within the allowable tolerance range. Using 3D printing technology to create a plug gauge offers several benefits, such as high accuracy and light weight, making it an attractive option for certain applications.

- The use of 3D printing in medical applications has been growing in recent years. For example, in the prosthesis assembly fixtures that are used in the manufacturing of prosthetic devices to ensure precise alignment and assembly of components, or to guide the placement of screws or other fasteners. Catheter manufacturing jigs are utilized to hold the catheter tubing in place during the bonding process or guide the placement of components such as balloons or stents.

8 Scale Your Manufacturing with Multiple 3D Printers

- When multiple 3D printers are used in factory settings, there are various considerations to ensure the printing process runs efficiently. Sufficient space must be available to accommodate not only the 3D printers but also material storage, post-processing stations, and ventilation that may be required for some 3D printing technologies. The workflow, including scheduling jobs, managing material usage, and handling post-processing and finishing tasks, may require specialized software or tools to automate and streamline the process. For example, Raise3D's printing management software, RaiseCloud, can remotely monitor, plan, control, and report the team's entire print production. This software allows companies to easily manage any number of users, printers, and print tasks in one customizable module. With RaiseCloud, users can control workflow management, monitor relevant data, and remotely modify parameters with a click of the mouse. To learn more about RaiseCloud, please click here.

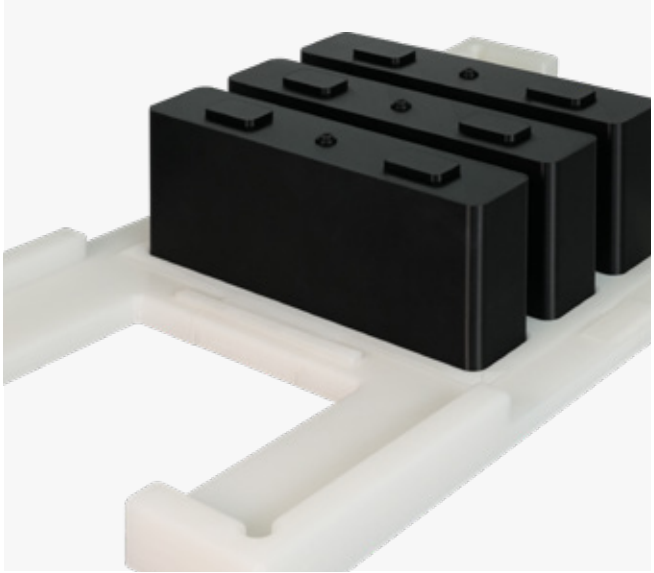


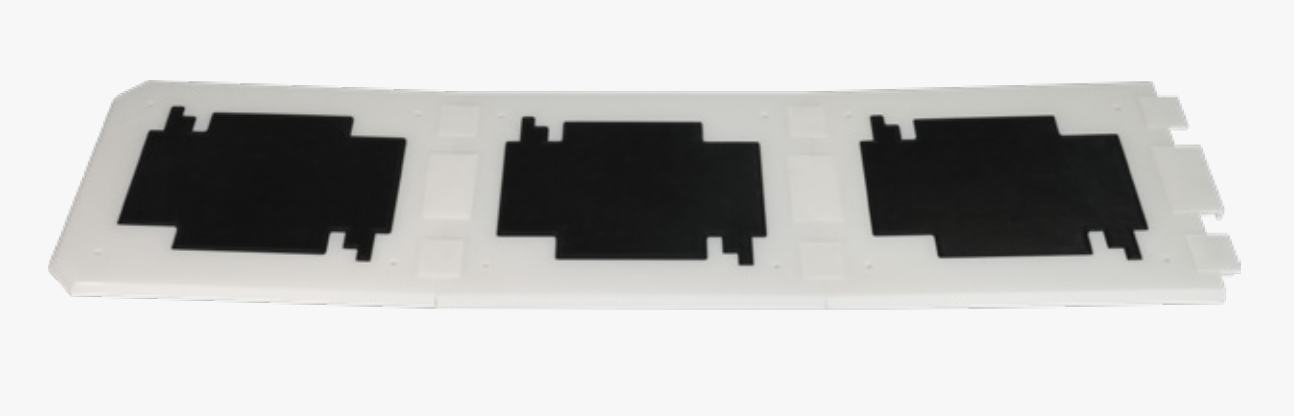
9 Conclusion

- Businesses that are proactive in exploring new technology for manufacturing are in a stronger position to remain agile and competitive in uncertain times, as seen during the COVID-19 pandemic. As with other manufacturing equipment, it takes time to learn how to use a new 3D printer, set up the workflow, install new software, and then train employees to operate the machine and implement new protocols.

- However, the time spent here is well-invested and also represents a fraction of the time needed to create jigs and fixtures using traditional methods. The advantages are evident, from the previously mentioned shortened production times to huge cost savings and a flexible and easily adaptable production line.

- Get started by contacting Raise3D today to discover how 3D printing can help your manufacturing.





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