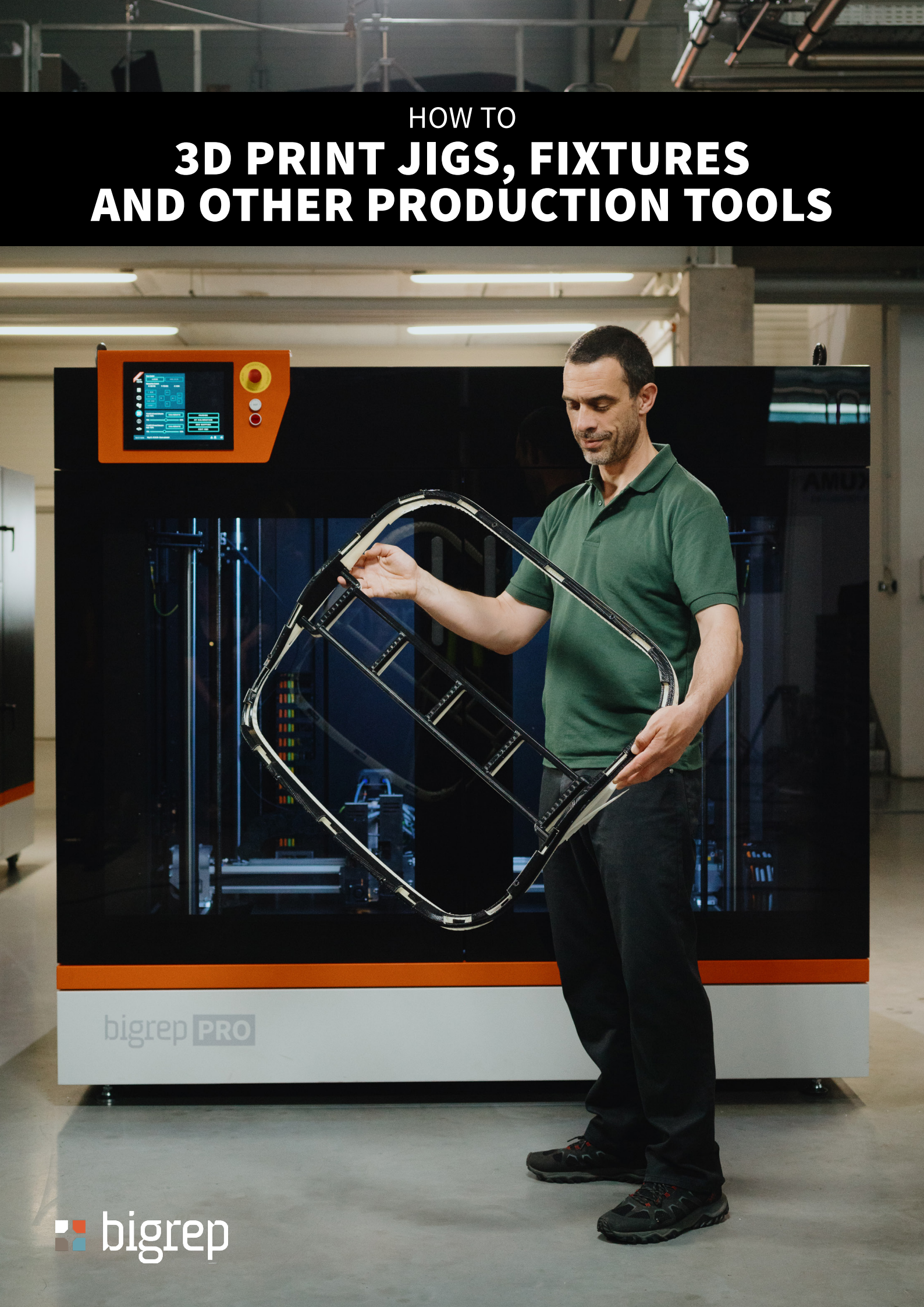
HOW TO

3D PRINT JIGS, FIXTURES AND OTHER PRODUCTION TOOLS



bigrep

INTRODUCTION

How to 3D print jigs, fixtures and other production tools to support manufacturing processes

When talking about production processes and the relevant equipment, most people think of large milling machines, hydraulic presses, injection molding machines, or robots assembling cars and other industrial goods. While this is true, there are also small and seemingly unremarkable tools used throughout various manufacturing steps, namely jigs and fixtures. These tools prove to be indispensable for the production process, saving time and making workers' lives easier. The use of additive manufacturing, more commonly know as 3D printing, to produce jigs and fixtures can be a breakthrough for engineers, production planners, and factory workers to produce the right tool for the right task.

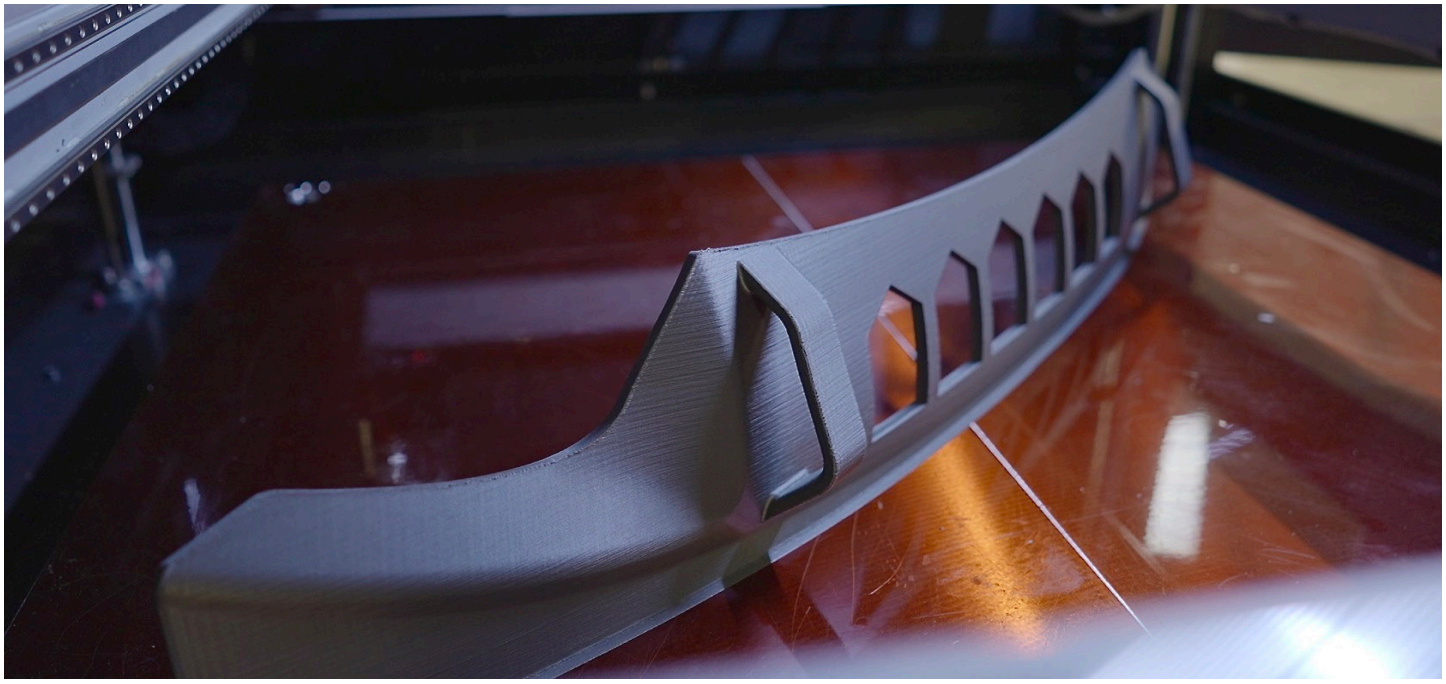
WHAT ARE JIGS & FIXTURES?

Both jigs and fixtures are tools used to keep a workpiece in a desired position or move it in a certain direction. In the early days of industrialization, jigs and fixtures were distinguished by the relative movement of tool and object [1]:

- A jig moves the workpiece relative to a tool.
- A fixture keeps the workpiece in a fixed place, while the tool is moving.

In the meantime, this strict distinction has softened. Nowadays the terms often get mixed up or confused, and the expression “jigs & fixtures” now commonly refers to all kind of equipment that helps to position, handle, store, measure, qualify, and organize not only workpieces, but also measuring equipment, sensors, other tools, and production aides.

A good example for such a tool is the drill jig often used by carpenters. By keeping the drill bit in its proper location and orientation, holes can be drilled into wooden objects in the exact right position. Strictly speaking, this would be a fixture, as it is the tool that is moving in relation to the workpiece. In an industrial context, the jigs and fixtures used to support the many different manufacturing processes are often much more complex.



[1] Colvin, Fred H.; Haas, Lucian L. (1938). Jigs and Fixtures: A Reference Book. New York and London: McGraw-Hill Book Company.

WHAT ARE THE REQUIREMENTS?

Modern manufacturing processes are extremely diverse, and so are the tasks the tools must perform. Therefore, depending on the individual process, jigs have to fulfill many different requirements.

Accuracy

In most cases, a jig or fixture will physically interact with the workpiece and (at least) one more object like a tool or vise. To make sure that the workpiece is securely held in place while the position of the other object fulfills the requirements specified by the manufacturing process, a high level of accuracy is typically necessary.

Strength and Durability

In some cases, like in a measurement environment, the loads on the tool are low, while in others, a jig might have to withstand the forces exerted on it by a milling cutter. This has to be taken into account during the design phase and the manufacturing process for a tool has to be chosen accordingly. In addition, some jigs or fixtures are used only once, while others are intended for year-long use. Certain tools are expected to last for many years while keeping their properties. Alternatively, there must a possibility to rework the tool.

Flexibility and Availability

Nowadays, one of the most crucial factors for being successful on the market is a fast development process. Many iterations and therefore many variations of a part are required to find the best possible solution for your product, and very often, this necessitates new, redesigned tools within a short period of time. Long lead times for the (often outsourced) production of tools can delay product development and jeopardise a company's success.

Costs

Like any tool, jigs and fixtures contribute to the overall cost of a product. The fewer workpieces that are produced using a tool - for example, if a tool serves low volume production or an ever changing prototype - the higher the impact of tooling costs on the final product price. This is especially true during the development phase, where sometimes they are used only once before a design is changed and a new tool is required. So it is imperative to keep the tooling costs down, while making sure that the jigs and fixtures are fully capable of fulfilling their tasks.

HOW ARE THEY MADE?

How are jigs and fixtures conventionally made?

Due to the complexity of their tasks and uses, the way jigs and fixtures are made differs vastly. However, it can be said that most are still made from metal, which includes manufacturing processes like welding, CNC machining, drilling, and grinding. Most commonly, a combination of two or more of these processes is required, which makes tool production very time consuming. While metal parts provide the required strength to hold and secure workpieces, they are quite heavy. This can be a drawback, especially in applications where handheld devices are repeatedly handled by workers.

The larger the tool, the more production and assembling of multiple parts is required. While this of course contributes to the costs and lead times, it also poses a risk to the tool's accuracy. If, for these reasons, a jig or fixture has to be produced as a single part, large format machines are often necessary to guarantee that the tool fulfills the requirements.

HOW ARE THEY MADE?

How can you employ 3D printing to overcome these problems?

As we have seen before, choosing a strategy and manufacturing method for your tools, jigs, and fixtures can have a massive impact on quality, costs, and lead times. This is not only true for production processes, but also for research and development phases in your product's lifecycle.

To summarize the information from the previous chapter, the perfect jig is:

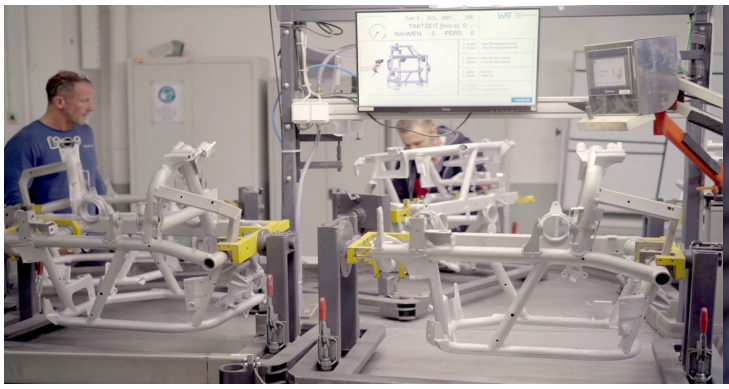
- Strong enough to withstand the loads and forces that are applied during the manufacturing process,
- Sufficiently precise to allow all of the intended manufacturing steps to be performed without any adverse effects,
- Cost-efficient to help achieve a competitive price for the final product,
- Easily adaptable to avoid extended standstills in the development process due to changes in the workpiece's design, and
- Can be produced fast enough to enable implementation of short-term changes and adaptations.

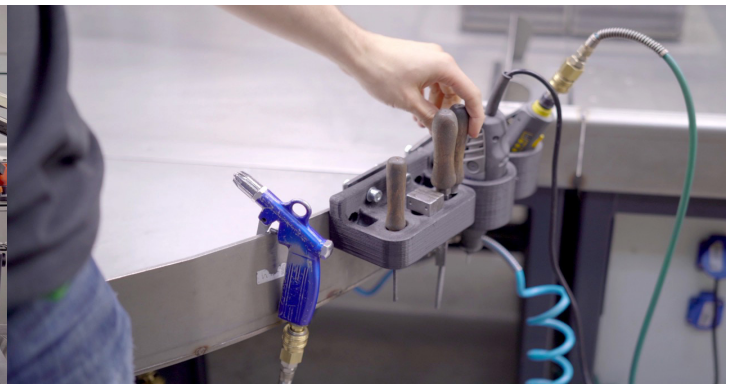
Please note that the aesthetic appearance of such a tool plays a secondary role in such an application. Even though some tools can have a very pleasing appearance, in an industrial environment surface quality and specific haptics are only required for either mechanical or human-tool interfaces.

So how does this lead us to 3D printed jigs and fixtures? In short, objects that are produced using additive manufacturing techniques fulfill all of the above requirements. Some who already had a 3D printed plastic part in hand might wonder if this is actually true. But a closer look into the details will reveal the huge potential of 3D printed parts.

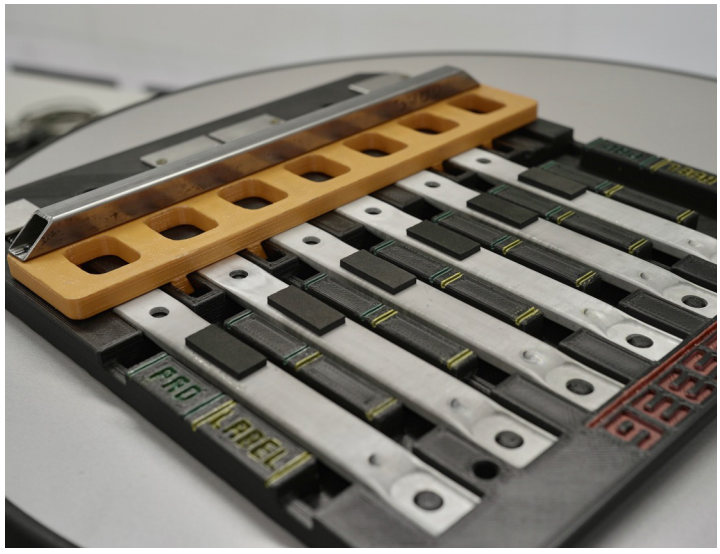
On the following pages we want to show you a few examples of how our customers have boosted their production processes, made manufacturing steps more efficient, and simplified repetitive tasks for their workers.

USER STORY: WAT SAVES 50% OF TIME IN QUALITY ASSURANCE

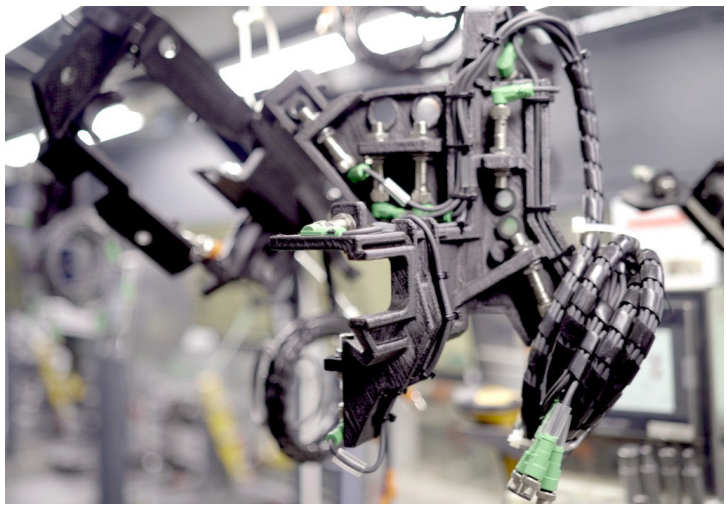




Walther Automobiltechnik (WAT) manufactures, among other products, complex steel and aluminum tube frames that are mainly used in cars and motorcycles. To produce these frames, tubes are bent and welded, holes are drilled in the right places, and reinforcement plates are added to create a complicated structure with many interfaces. In order to perform a quality check, the frame's dimensions including size and position of all features must be measured and the values stored in the product's database. The measurements are taken using calipers, Go/NoGo gauges, and optical devices. As most of these steps are done manually and could potentially be performed incorrectly, the validity of measurements had to be ensured by employing the "Four Eyes" principle, tying up workers and causing higher costs.



Now WAT 3D prints jigs that hold a large number of sensors and gauges in place. By putting the jig onto a frame, where it is held in place by magnets, many measurements are taken at the same time. Since the gauges cannot be used in a wrong way any more, the data can be sent directly to the database without the need for a control loop by a second operator. This leads to time savings of more than 50% for WAT.



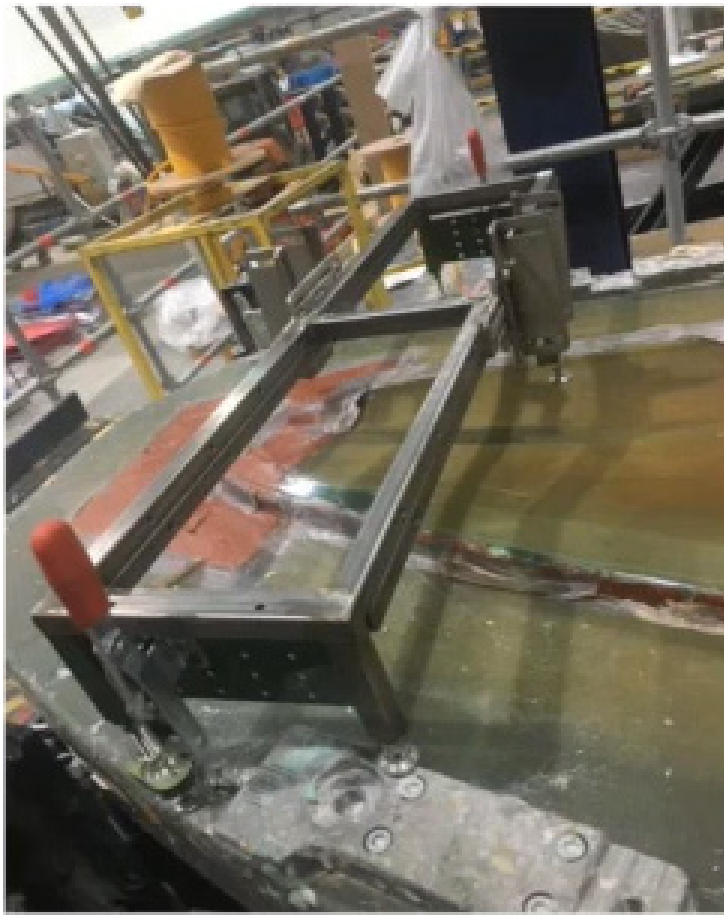
WAT uses their BigRep 3D printer for more than just QA tools. Various production processes have been examined for their optimization potential, which has lead to several other jigs and fixtures. Among those there are shadow boards and part containers that minimize error sources according to the "Poka Yoke" principle, or holders that make sure that work surfaces stay free of tools, while keeping them readily available at the workplace.

USER STORY: VESTAS REDUCES COSTS FOR ASSEMBLY TOOLING BY 70%

Vestas designs, builds, manufactures, and installs large wind turbines. During blade assembly, special fixtures are required to hold parts in place as well as maintain a consistent positioning from one blade to the next. To replace the heavy, welded steel fixtures that had a long lead time, Vestas were looking for a faster and more cost efficient way to provide the assembly teams with adequate tooling.

As a result, Vestas designed a 3D printable fixture that is lighter as well as modular and, therefore, more versatile. The lead time was reduced by several weeks and the production costs lowered by more than 70%. This was made possible only because their large-format 3D printer, BigRep's Studio G2 (Vestas has a G1), allowed them to print the huge parts required for manufacturing large workpieces.

But engineers at Vestas didn't stop there. Having a large-format 3D printer at their disposal allowed them to 3D print other parts that made the complicated and demanding assembly of wind turbines safer and easier. Vestas made an interesting discovery: making tools for assembly and QA on their 3D printer was so cost-efficient and fast that they could produce much more of them, and this in turn increased product quality. Jeremy Haight, Principal Engineer at Vestas: "By having Additive Manufacturing in our pocket, we were able to flood the floor with quality tooling, by which we enable our regular production workers to do more of the important spot checks, which results in better quality."



USER STORY: FORD'S BIGREP ONE MET ROI AFTER JUST THREE PRINTS

At Ford, engineers were looking for a way to produce a large-scale fixture to measure the gap between the car body and door. This tool needed to be the size of the door opening and precise enough to guarantee a reliable measurement. Being a handheld device, its weight was important as it would be repetitively lifted by workers. Additionally, Ford needed to quickly adapt the tool as design changes resulted in new frame sizes and shapes. Ford engineers found a solution using their BigRep ONE to design a sturdy, yet lightweight 3D printed gauge. Comparing 3D printing to other manufacturing options, Ford found that the BigRep ONE had amortized after only three of these gauges had been printed.

From then on, various departments at Ford found uses for the large format 3D printer they now had at their disposal.

These are only a few of the ideas engineers at Ford came up with, which were printed and used in the production process:

- Positioning devices for decals and logos
- Assembly jigs for complex groups of parts
- Mock-ups of car parts for assembly planning
- Placeholders for components that would be installed later
- Protectors to avoid damage to parts that needed to be handled manually

CONCLUSION

PROBLEMS OF TRADITIONAL FACTORY TOOLING	SOLUTIONS WITH 3D PRINTED FACTORY TOOLING
Expensive material and labor costs	Minimal material and labor cost
Slow to iterate and produce	Agile production easy to iterate and customize
Large, costly inventory storage	Digitized with no physical inventory
Heavy and non-ergonomic	Lighter and topology optimized
Outsourced to third party supplier	Produced in-house on demand
NDA required for external providers	Design knowledge is protected in-house

In virtually every industry, many tools are required that support the final manufacturing process. This is especially true for highly complex and demanding industries, like automotive and wind turbine production, where time is precious and mistakes are costly. In these environments, each change to an established process is diligently planned and closely monitored after implementation and it's clear that large format 3D printing has proven its worth. Additive Manufacturing is cost efficient, easy to integrate into manufacturing processes, and capable of fulfilling all technical requirements. Companies that publicly championed their use of large format 3D printing include such notable enterprises as Mercedes-Benz, Nissan, Siemens, and many others from a wide range of different industries, many of which are in fact using BigRep printers.

But the new manufacturing method does not only solve a specific need at all of the aforementioned firms.

Large format additive manufacturing does more than just provide real solutions for some of the world's most recognized companies. It also triggers their employees' creativity allowing them to reconsider old processes to find new and innovation ways forward. Being able to turn their ideas in existing parts at the touch of a button gives rise to completely new solutions that had been unthinkable before.

If you are interested in learning more about large format 3D printing, or if you want to know how additive manufacturing can support you and your business, do not hesitate to ask! Our expert team will happily answer all your questions. If you already have a part in mind to 3D print, feel free to send us your 3D file. We will analyze it and give you a detailed print report that contains all the information you need to calculate the additional value that 3D printing can bring to your company.

UP TO 1 M^3 LARGE-FORMAT, INDUSTRIAL 3D PRINTERS

Built to take you from prototyping to production.

A global leader in large-format FFF 3D printing, BigRep strives to transform its users' productivity and creativity with easy-to-use additive manufacturing solutions. With an aim to help companies accelerate innovation and rethink manufacturing, BigRep's German-engineered 3D printers enable engineers, designers and manufacturers from start-ups to Fortune 100 companies to go from prototyping to production faster, getting their products to market first. Through collaborations with strategic partners – including BASF, Bosch Rexroth, Etihad Airways, and Deutsche Bahn – BigRep continues to develop complete additive manufacturing solutions comprising of industrial 3D printers, software, and advanced materials.

Founded in 2014, BigRep is headquartered in Berlin with offices and technical centers in Boston and Singapore.

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