Reducing Costs and Lead Time in Manufacturing with 3D Printed Jigs, Fixtures, and Tooling

in Interviews

What do Formula 1 race cars and Marine One have in common? Many of their high-performance drivetrain and engine components started life in Kapfenberg, a quiet little town nestled in the Austrian Alps.

Pankl Racing Systems specializes in developing and manufacturing engine and drivetrain components for racing cars, high-performance vehicles, and aerospace applications with more than 1,500 employees, and worldwide subsidiaries in Austria, Germany, the United Kingdom, the United States, Slovakia, and Japan.

Every single part that Pankl makes requires a series of custom jigs, fixtures and other tooling that are designed and fabricated specifically for that part. The result is a proliferation of custom tools, adding significant cost and complexity to the manufacturing process.

To fulfill tight production deadlines, process engineer Christian Joebstl and his team introduced stereolithography (SLA) 3D printing to produce custom jigs and other low-volume parts directly for their manufacturing line in the company's new €36 million state-of-the-art manufacturing facility.

While 3D printing was initially met with skepticism, it turned out to be an ideal substitute to machining a variety of these tools, surprising even Pankl's demanding engineers. In one case, it reduced lead time for jigs by 90 percent—from two to three weeks to less than a day—and decreased costs by 80-90 percent, leading to €150,000 in savings. Read on to learn how Joebstl and his team implemented their new 3D printing-based process.

Pankl has been in the business for more than 30 years. Has 3D printing been a long-standing part of your practice?

Surprisingly, not at all. We didn’t have any 3D printers until less than a year ago. A colleague of mine had a request for a custom cover to hide some areas from impact in a shot peening machine. We used to buy parts like this from an external supplier, and one such tooling cost about €1,200. I was thinking ‘there has to be another way.’ Having been familiar with 3D printing from my education, I started looking and found the Form 2 3D printer after reading some reviews online. My colleagues understand the value in 3D printing now, but at the beginning, they were extremely skeptical. They thought 3D printing was more like a toy.

In our business, we expect that good equipment is inevitably also expensive. Most of our machinery starts at €100,000 and goes well beyond that. When my colleagues saw that the Form 2 only costs about €3,900, they asked me, “Why should we buy a toy?”

We ordered multiple custom sample parts to conduct tests, and it turned out that the 3D printed parts were capable. Holes and length tolerances were within the ±0.1 mm interval. I researched the material costs for my amortization calculation and discovered that a 3D printed set of the tooling for shot peening would only cost €45. I summarized this into a presentation for the board and took the parts to the kickoff meeting of the new gear plant. They were finally convinced, and we decided to buy our first Form 2, which we soon scaled up to three units.

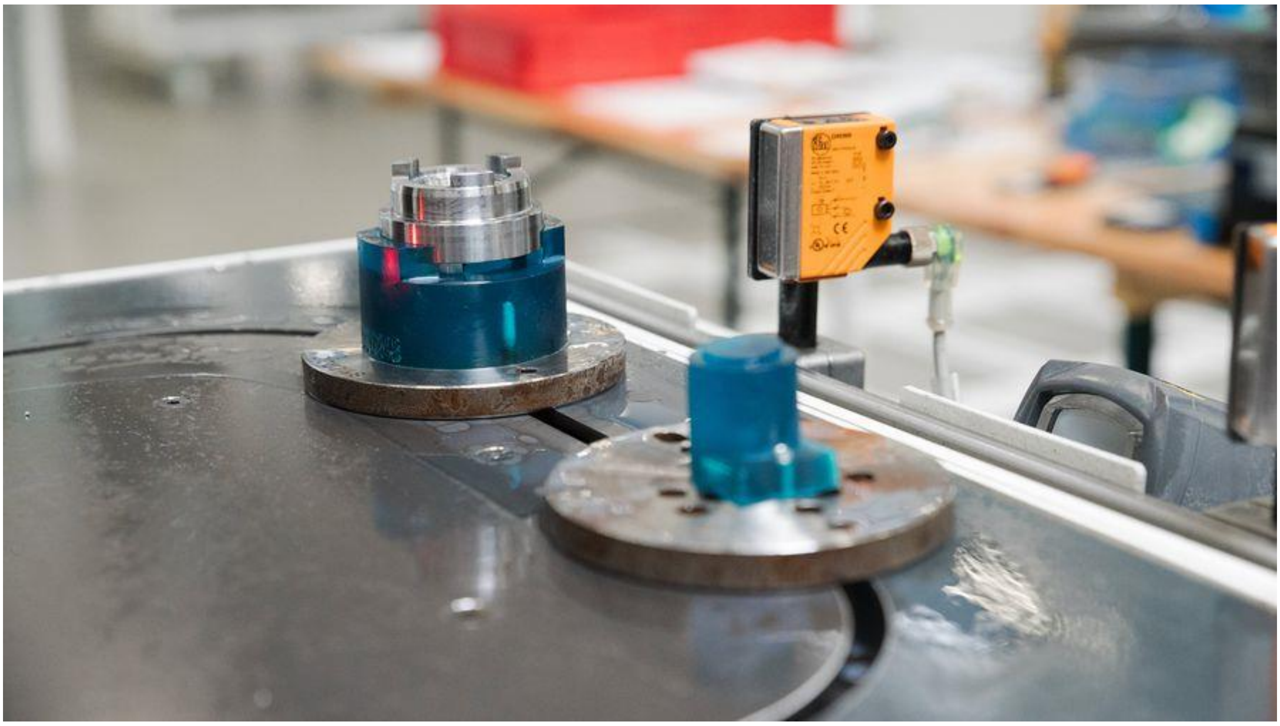
Process engineer Christian Joebstl runs three Form 2 SLA 3D printers in Pankl’s production facility.

In what cases has 3D printing helped trim production timelines and save costs?

Pankl was selected to manufacture entire gearbox assemblies for a well-known motorcycle manufacturer in 2016, and we swiftly began to set up the new production facility. Manufacturing these gears is an elaborate process. Forged steel parts go through multiple stages of machining using automatic lathes, followed by heat treatment and stress relief.

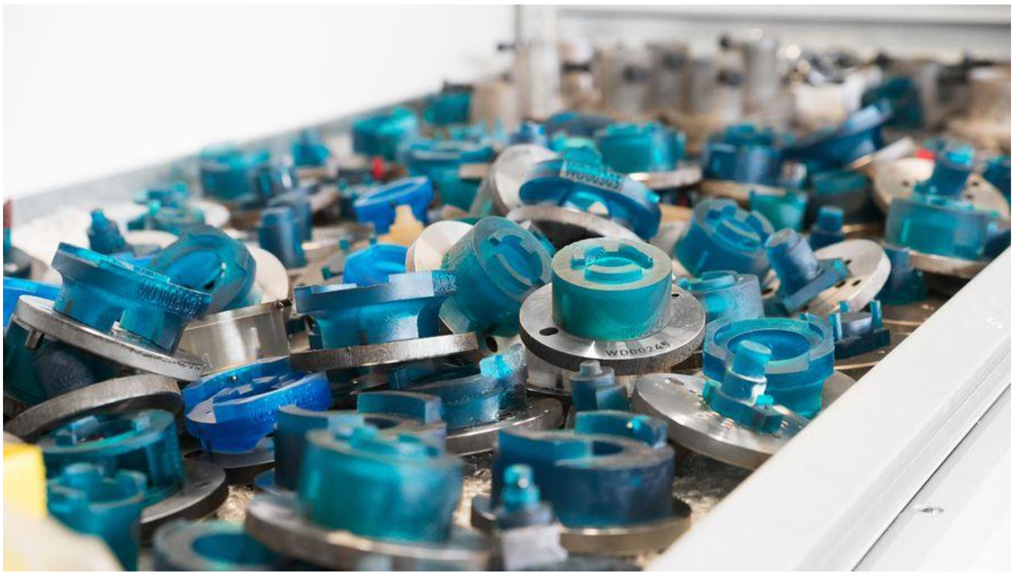
Each stage of turning in the automatic lathes requires custom jigs for every individual gear type. Machining these parts is costly, and adds significant complexity and risk to the manufacturing process.

Our schedule was tight because we had to produce many more gear types than expected. By the time we got to designing and ordering tooling, we were already supposed to start producing the first acceptance lots. We couldn't just design the custom jigs and get them next day. If we had outsourced to traditional machining service providers, we would have had to wait six more weeks before we could start production - so we decided to produce the parts in-house on our Form 2 3D printers.



Each working stage in the automatic lathe requires a custom jig. The jigs are attached to the conveyor belt using standard shuttles.

With 3D printing, you can simply take the same design, send it to the printer, and then have the finished part ready by the next morning. This leaves time to check the part on the manufacturing line and make any necessary changes. It also simplified the design process, providing the design freedom to produce jigs in any shape. In conventional CNC milling or turning, you are constrained by the need to design machinable parts, and every extra curve, hole, or chamfer adds complexity to the process.

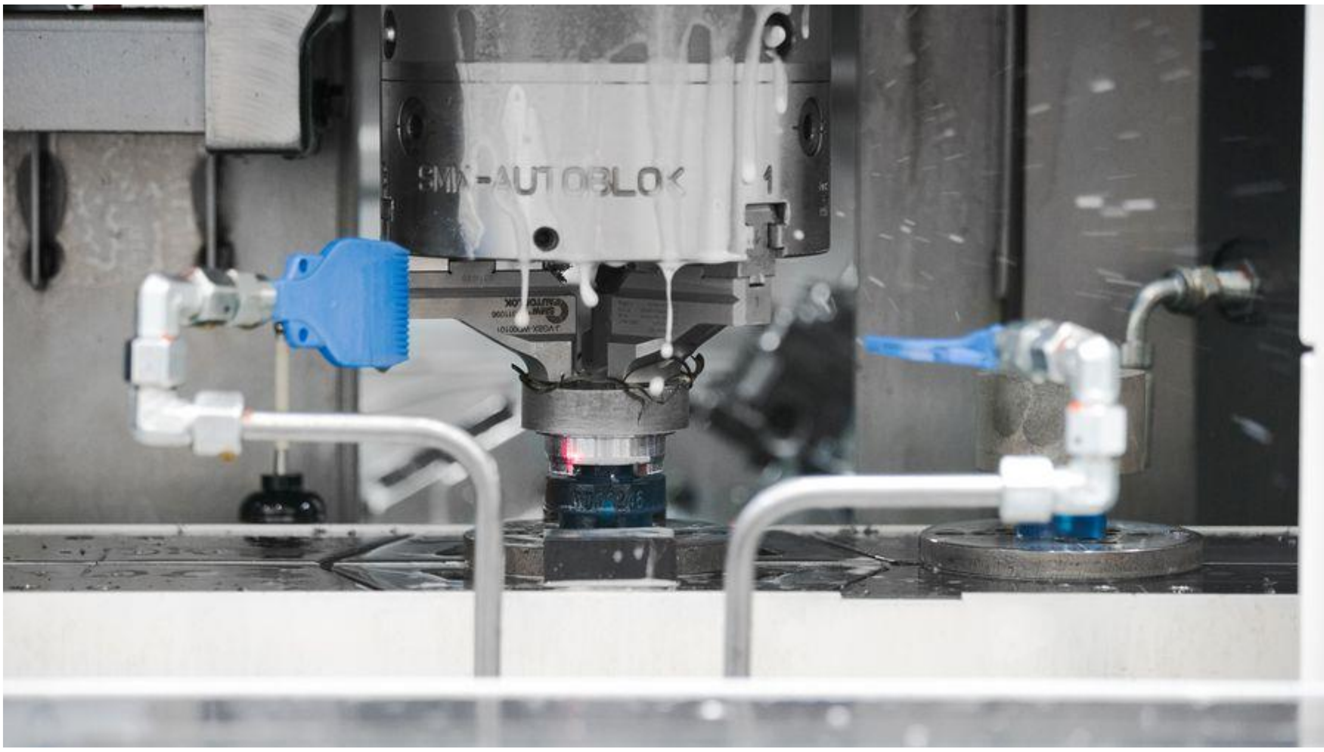


Each jig is printed with a unique identifier on its side.

Using a single Form 2, we can print a single jig in 5–9.5 hours, and running all three of our machines enables us to produce about 40 jigs within a week.
A simple machined jig costs about €40–50, but more complex parts can cost up to €300. 3D printing reduces these direct costs to €8.5–25, and significantly lowers overhead costs in design, purchasing, and storage, resulting in more than 90 percent overall cost reduction. Considering we'll have to produce more than 1,000 jigs over the course of production, 3D printing will help the company save more than €150,000.

How did these parts fare on the production line?

We've had lots of problems in the past because the cooling media in the lathe is very aggressive on plastic parts, and makes them brittle after some time. Parts 3D printed with Tough Resin have shown resistance against our cooling media, and they are strong enough to withstand the intermittent load that these parts have to endure. Holes and length tolerances normally lie within the ±0.1 mm interval, which satisfies the requirements for our jigs.



A machine gripper picks up the part from the first jig, and places it on the second jig once the machining process is complete.

We've already produced more than 300 3D printed jigs to manufacture small batches of 200 parts of each gear for the trial production run. Soon, we'll scale up production to 1,000-2,000 parts per batch and the production capacity of the facility will increase to more than 1.5 million gears per year.

What are some other applications where you have used 3D printing?

Prototyping, shot peening, masking and manufacturing various jigs and tooling. For example, when we have a new connecting rod design, we 3D print prototypes to discuss complex features on the part. It's much easier if you can look at the part, and hold it in your hands.

Once we had to design a custom connecting rod for a customer, who wanted to verify if it'd fit into the building room of a cylinder and that it wouldn't hit the chamber or the cylinder head itself while turning. We 3D printed a prototype and sent it to them. Once they confirmed that the design worked, we could start production with confidence. The alternative would have been to produce a machined part, which would have been more expensive for the customer and required eight weeks of waiting time.

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We also 3D printed special adapters for grippers on an automated handling system. To achieve the perfect grip between the gripper and the part, you have to take the negative of the part, and form the fingers of the gripper according to the shape of your part. Normally we would have milled or cast it, which would have been substantially more expensive.

Recently, we used Flexible Resin in a shot peening machine to increase the friction between the self-cleaning jigs and some other parts. The friction between the metal parts was too low to transfer the turning movement. I added some 3D printed elastic brakes in the tooling to increase the friction so that the turning movement was transmitted from the bottom to the top. Getting these parts from an external vendor would have taken weeks.

Do you have any other plans to use 3D printing within Pankl?

One of my goals is to get more orders from other divisions within Pankl. We've had success with 3D printed parts in our production line, and I see countless other applications that could benefit from 3D printing. I want to show other engineers the parts we make, and the applications where we use them, to make them aware that this technology is available to them in-house.

I started with this project when other colleagues showed interest in our new processes. I sent around information on the 3D printing materials, such as their mechanical properties, what they look like, and the particular use cases they're suitable for. I also printed sample parts for other departments, described the design specifications and how they can order something.

Request a Free Sample

We've already printed parts for aerospace and drivetrain divisions. They send us the designs, we produce the parts for them, and they receive finished parts that are ready to use in their machines. Pankl is a large company, though, which makes this a slow process. We have to overcome the same hurdles as we did initially within our department, and I believe many other companies have these concerns about 3D printing. But looking at the results we've achieved, I'm positive that they'll recognize the value in the technology.