TRUMPF

Whitepaper

TRUMPF uses 3D printing to improve the aerospace industry

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Abstract

In the aerospace and aircraft industry, it's crucial that components are lightweight and robust. When these two characteristics are not achieved, costs increase tremendously and parts are more likely to return damaged or completely ruined due to extreme conditions.

How can you ensure that your components consistently achieve a lightweight and robust design? The answer is additive manufacturing with TRUMPF. With outstanding precision and flexibility, TRUMPF 3D printing systems have had a huge impact on the aerospace industry. TRUMPF additive production systems – TruPrint 1000, TruPrint 2000, TruPrint 5000 and TruLaser Cell 3000 – are perfect for production, coating and repair through laser metal fusion and laser metal deposition. Read more to learn how TRUMPF is improving the aerospace industry with additive manufacturing.

Situation

Satellites are subject to a whole array of ever more stringent requirements. On the one hand, they need to be as light as possible, because every pound that a launch vehicle carries into space costs the client several hundred thousand dollars. At the same time, however, satellites must be robust enough to withstand the tremendous forces experienced during launch.

Figure 1:
Trust TRUMPF to provide efficient aerospace components.

The solution

TRUMPF demonstrates how additive manufacturing can improve satellites and aircraft. “With a market share of over 20 percent, the aerospace sector is one of the world’s most important industrial users of additive manufacturing. We are steadily expanding our market share and helping to establish the process as a key technology,” says Thomas Fehn, TRUMPF general manager additive manufacturing (AM) with responsibility for sales.

Weight reduction is very important for aircraft because it leads to a significant drop in fuel consumption. This reduces both their environmental impact and costs. Additive technologies are the perfect match for the aerospace industry because they enable engineers to create parts that are both lightweight and robust. These methods only add material where it is actually needed, while conventional methods such as milling and casting often struggle to eliminate superfluous material. 3D printers are also adept at handling light metals such as aluminum and titanium, and AM engineers enjoy much more freedom in the design process because they are not confined by the limitations of traditional production methods.

Figure 2:
TRUMPF has 3D printed a mounting structure for a communications satellite.

Three examples of how 3D printing is improving the aerospace industry:

01

Weight of satellite mounting structure reduced by 55 percent

TRUMPF has been commissioned by the space company Tesat-Spaceroom GmbH & Co.KG to produce a 3D-printed mounting structure for Germany's Heinrich Hertz communications satellite, which will be used to test the space-worthiness of new communication technologies. The mounting structure includes strap-on motors that are used to modulate microwave filters. In collaboration with the company AMendate, engineers succeeded in optimizing the topology of the mounting structure and reducing its weight by 55 percent. The mount now weighs just 2.64 ounces rather than 5.78 ounces. "This is just one example of how we can use additive processes in satellite construction to reduce weight and increase payload capacity," says Matthias Müller, Industry Manager Additive Manufacturing for aerospace and energy at TRUMPF. The team of experts printed the redesigned part on TRUMPF's TruPrint 3000 3D printer. The new geometry cannot be produced using conventional methods. As well as being lighter, the optimized mounting structure is also more robust. During the launch of the satellite the new mounting structure will withstand the same high forces and will hold its shape better. The Heinrich Hertz satellite mission is carried out by DLR Space Administration on behalf of the Federal Ministry of Economics and Energy and with the participation of the Federal Ministry of Defense.

02

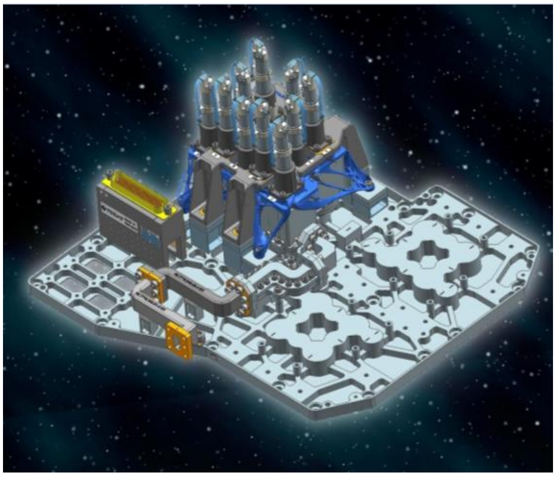
Cost of engine parts reduced by three quarters

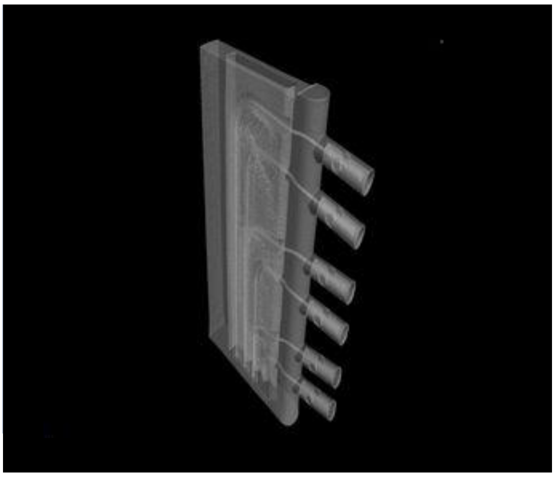
In collaboration with Spanish supplier Ramem, TRUMPF experts have employed 3D printing to optimize a part known as a "rake." Manufacturers use this part during engine development to measure the pressure and temperature of the engine. These kinds of measurements are an important part of testing aircraft performance. Mounted directly in the engine's air flow, rakes are exposed to extreme temperatures and high pressure. To deliver accurate measurements, they must conform to precise dimensional requirements. Producing rakes by conventional means is an expensive and time-consuming process. Workers produce the base structure on a milling machine before inserting six delicate tubes, welding them into place and sealing the body of the rake with a cover plate. If just one of these tubes is out of place, the rake has to be scrapped. TRUMPF produced an optimized rake geometry on the TruPrint 1000 3D printer. Redesigning the part in this way makes it quicker for the manufacturer to produce and reduces the amount of material used by around 80 percent, ultimately slashing the overall cost by 74 percent. "This result shows that 3D printing can save a significant amount of time, material and money in the aircraft industry," says Project Manager Julia Moll from TRUMPF Additive Manufacturing.

03

Making engine blades easier to repair

TRUMPF uses Laser Metal Deposition (LMD) to repair a high-pressure compressor blade – also known as a 3D aero blade – used in aircraft engines. These components have to withstand extreme changes in temperature during flight. They are also in constant contact with dust and water, and they typically show signs of wear on the edges and tips. Aviation engineers have to periodically repair the blades to maintain engine efficiency. The LMD method is perfect for this job. In some sections of the blades, the material is just 0.2 millimeters thick. Conventional methods quickly reach their limits in these kinds of applications. With LMD technology, however, the laser can be positioned with an accuracy of approximately one hundredth of a millimeter before it applies a precisely calculated dose of energy. At the same time, the system feeds in material of exactly the same composition as the part itself. Depending on the application, this process typically takes just a few minutes. It makes it easy to repair the blades multiple times, significantly reducing the cost per part in each engine overhaul. "Laser Metal Deposition delivers a low dose of energy – and that makes it perfect for aerospace applications. We can use it not only to repair and coat parts, but also to build up three-dimensional structures. That's simply not possible with conventional welding methods," says Oliver Müllerschön, head of industry management laser production technologies at TRUMPF.





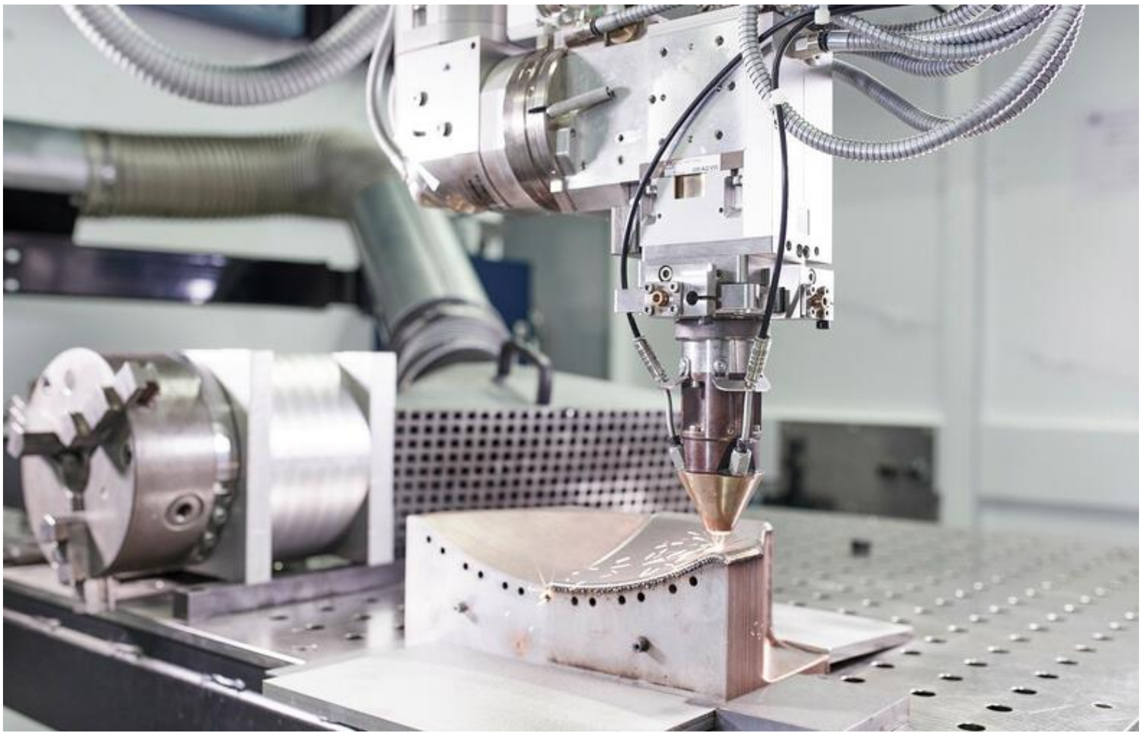
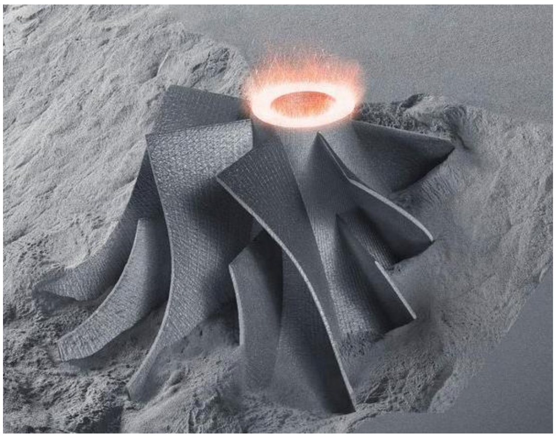


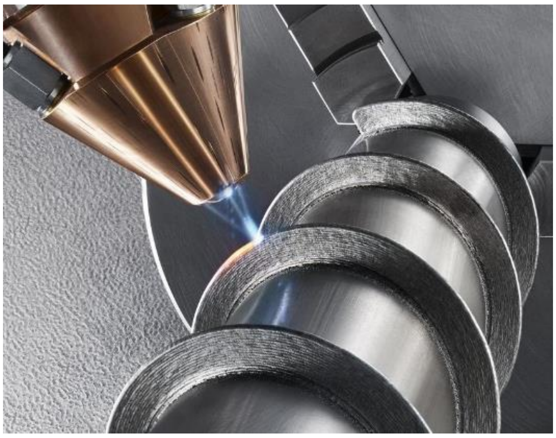
Figure 1–3:
The following figures represent the three different examples of how 3D printing is improving the aerospace industry. Figure 1 shows a 3D printed mounting structure, figure 2 shows a 3D printed rake, and figure 3 shows the production of a 3D printed aero blade.

Process

TRUMPF offers expertise in both the key methods required by the aerospace industry: Laser Metal Fusion (LMF) and Laser Metal Deposition (LMD). “Thanks to our LMD and LMF capabilities, we are perfectly placed to offer our aerospace customers 3D printing solutions that match their needs,” says Fehn.

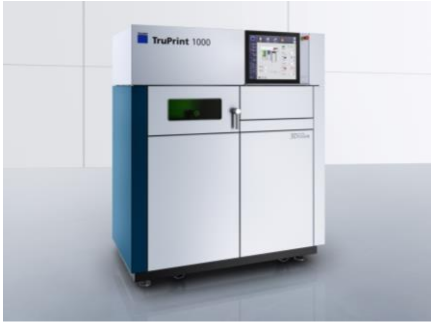


Laser Metal Fusion:
Laser Metal Fusion (LMF) is carried out entirely within the confines of the 3D printer, with a laser building up the part layer by layer from a powder bed. A CAD model provides the plan for doing so, and no tools are required. The powder is added to the build platform. The laser beam accurately melts on the powder according to the CAD data and joins defined points to the layer underneath. The laser then repeats this process until the metal part is finished. The workpiece has the same properties as the metal powder which was used. LMF technology is particularly suitable for creating complex parts for engines, combustion chambers, specialist aerospace components and similar applications.



Laser Metal Deposition:
Laser Metal Deposition (LMD) uses a laser beam to build up layers on the surface of a part, with the metal powder being injected through a nozzle. First of all, the laser beam heats up the workpiece locally, creating a weld pool. Fine metal powder is sprayed directly into the weld pool from a nozzle in the processing optics. It melts there and combines with the base material. A layer of approx. 0.2 to 1 millimeter remains. If required, numerous layers can be built upon each other. Argon is often used as the shielding gas. To apply lines, areas, and shapes, the automatically controlled processing optics move over the workpiece. An intelligent sensor system ensures that the layer thickness is even everywhere at all times. LMD can be used to rapidly generate very large parts. Typical applications include prototype development and repairs to large parts such as gas turbines and compressor blades.

Equipment



Technical Data

		TruPrint 1000	TruPrint 2000	TruPrint 5000
Build volume (cylinder)	mm x mm	Ø 100 x H 100 Optional: Smaller build volume	Ø 200 x H 200	Ø 300 x H 400 Ø 290 x H 400 (reduction if preheating is > 200 °C)
Processible materials[1]		Weldable metals in powder form, such as: Stainless steels, tool steels, aluminum[2], nickel-based, cobalt-chrome, copper, titanium[2] or precious metal[2] alloys	Weldable metals in powder form, such as: Stainless steels, tool steels, aluminum, nickel-based, cobalt-chrome or titanium alloys	Weldable metals in powder form, such as: Stainless steels, tool steels, aluminum, nickel-based or titanium alloys
Build rate	cm^3/h	2 – 18[3]	-	5 – 180[4]
Layer thickness[5]	µm	10 – 50	20 - 100	30 – 150
Laser source (TRUMPF fiber laser)	W	200 Optional multilaser: 2x200	300 Optional multilaser: 2 x 300	3 x 500
Focus diameter	µm	55 Optional: 30	55	-
Beam diameter	mm	-	-	100 – 500[4]
Measurable O_2 concentration	ppm	Down to 3000 (0.3%) Optional: down to 100 (0.1%)	Down to 100 (0.01%)	
Scan speed (powder bed)	m/s	Max 3		
Preheating	°C	-	Up to 200	Basic machine: up to 200 Option: up to 500
Unpacking in the machine		-	Integrated powder conveyer	-
Shielding gas		Nitrogen, argon		
Automation		-	-	Automatic process start
Power supply	V / A / Hz	230 – 7 – 50/60	400/460 – 32 – 50/60	400 – 32 – 50
Dimensions	mm	1445 x 730 x 1680 (incl. filter)	2180 x 2010 x 1400	4586 x 1628 x 2026 (incl. filter, electrical cabinet)
Weight	kg	650 (incl. filter)	3200	7085 (incl. filter, electrical cabinet, powder)
Filter unit		-	-	Self-cleaning, long-term, multi-material filter unit

[1] Current material and parameter availability upon request
[2] Available with optional packages
[3] Dependent on system configuration, process parameters, material and degree of filling
[4] Actual build rate consists of exposure and recoating. Dependent on system configuration, process parameters, material and degree of filling
[5] Individually adjustable

Subject to alteration. Only specifications in our offer and order confirmation are binding.

Equipment

Figure 1: The TRUMPF TruLaser Cell 3000.

Technical data		
Axis positioning range		
X	in	31.5
Y	in	23.6
Z	in	15.7 (+11.8)[1)]
B/C[2)]	°	± 135 /n x 360
Maximum payload	lbs	881.8
Speed		
X/Y/Z	ft/min	164.0
Simultaneous	ft/min	278.9
B/C[3)]	1/min	120/400
Acceleration		
X/Y/Z	ft/s^2	32.8
B/C[3)]	rad/s^2	125/500
Positioning deviation Pa		
Linear axes X/Y/Z	in	0.0006 (0.0002)[2)]
Rotational axes B/C[3)]	°	0.02/0.02
Laser		
Maximum laser power	W	8000[4)]
Available lasers		TruDisk, TruPulse, TruDiode, TruFiber, TruMicro
Available technologies		Laser welding, laser cutting, laser deposition welding
Rotating changer		
Diameter	in	34.3
Maximum payload per side	lbs	209.4
Stations	Number	2
Rotation time	s	3
Total typical nonproductive time	s	5.2
Dimensions		
Width / depth / height	in	63.0 / 111.8 / 104.3

[1] With additional W1 axis. [2] High-accuracy axis system. [3] C180 rotational axis. [4] Higher laser power upon request.
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Conclusion

TRUMPF offers efficient solutions for the aerospace industry, specifically solutions based on additive technologies. Easily repair damaged components or produce new ones with laser metal fusion (LMF) and laser metal deposition (LMD). Maximize your productivity, while saving money, time, and even material with TRUMPF additive production systems.

For more information on TRUMPF's additive production systems, please visit our website.

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