3D Steel Printing Takes Off on the International Space Station

Editor

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Steel entered the Space Age on 30 May 2024 when a 3D steel printer printed its first steel component on the International Space Station.

At the end of May 2024, a 3D metal printer on the European Space Agency's (ESA) Columbus Laboratory module on the International Space Station (ISS) revolutionized in-orbit manufacturing. In an out-of-this-world first, it created a small S-curve from liquefied stainless steel and proved that 3D steel additive manufacturing, the process of constructing an object one layer at a time, can be done in space.

"This S-curve is a test line, successfully concluding the commissioning of our metal 3D printer," explained ESA technical officer, Rob Postema. "The success of this first print, along with other reference lines, leaves us ready to print full parts in the near future."

Polymer-based 3D printers have been printing plastic objects on the ISS for some time, but metal printing was a greater challenge as it involves much higher temperatures and lasers to melt the metal. With this steel printer, a stainless-steel wire is fed into the printing area and then heated by a high-powered laser, which is about a million times stronger than a standard laser pointer. As the wire melts, the stainless steel is printed into the desired form.

The 3D steel printer was developed by a consortium comprising of Airbus Defence and Space, AddUp, Cranfield University, and Highftech Engineering, under a program funded by the ESA.

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Safety First

Protecting the ISS from the aggressive printing environment caused by the laser and the heat it generates was initially a problem, said Sébastien Girault, metal 3D printer system engineer at Airbus. "The printer sits in a sealed metal box, which acts like a safe. The melting point of metal alloys compatible with this process can be far over 1,200°C, compared to around 200°C for plastic, which implies drastic thermal control.

"Gravity management is also key, which is why we chose wire-based printing technology. The wire is independent of gravity, unlike the powder-based system, which always has to fall to the ground."

Having surmounted this obstacle, the strength, conductivity and rigidity of metal opens up huge opportunities for 3D printing in space.

European Space Agency astronaut Andreas Mogensen installs the printer that enables 3D steel printing on the ISS. Photo courtesy of European Space Agency.

Operated From Earth Printed in Space

The printer, which is about the size of a microwave oven, is controlled by operators on Earth at the CADMOS User Support Centre in France. All the ISS crew have to do is open a nitrogen and venting valve to allow printing to begin.

To test the possibilities of the stainless steel printer in space, it will initially print a few predetermined shapes, which will then be returned to Earth so that they can be compared with the printing quality and performance of the same prints made on the ground with normal gravity. Scientists will compare data from both the tests undertaken in space and on Earth to understand how the process and the metal are affected by microgravity.

"Two of these printed parts will be analyzed in the Materials and Electrical Components Laboratory at ESTEC in the Netherlands, to help us understand whether prolonged microgravity has an effect on the printing of metallic materials. The other two will go to the European Astronaut Centre and the Technical University of Denmark, DTU," revealed ESA materials engineer Advenit Makaya from the ESA's Directorate of Technology, Engineering and Quality.

Creating a Circular Economy in Space

The ESA plans to use the 3D stainless steel printer to help create a circular economy in space. To extend the life of space equipment and optimize resources, it hopes that once fully operational it can be used to print parts and tools needed in orbit, avoiding the need to have them delivered by rocket from Earth.

"Metal 3D in space printing is a promising capability to support future exploration activities, but also beyond, to contribute to more sustainable space activities, through in-situ manufacturing, repair and, perhaps, recycling of space structures, for a wide range of applications. This includes in-orbit large infrastructure manufacturing and assembly, as well as planetary long-term human settlement. These aspects are key focuses in the ESA's upcoming technology cross-cutting initiatives," said Tommaso Ghidini, head of the Mechanical Department at the ESA.

If only the early pioneers of steel could see how far the metal has gone literally and figuratively! ✦