ATHENA AIMS FOR THE STARS WITH ADDITIVE MANUFACTURING

The task of the Advanced Telescope for High-Energy Astrophysics (Athena) is to research temperature and energy flow in the universe. The European Space Agency (ESA) selected the underlying concept for the mission in 2013 as one of the most urgent scientific topics for a major future space mission. Fraunhofer IWS provides an optical bench that is one of the three main components.

How did the large-scale structures of the universe originate? How did black holes grow and how did they shape the universe? Athena's task is to help answering these questions by combining locally resolved X-ray spectroscopy with in-depth, large-surface and energy-dispersive radiograms. The intent is that the performance of the telescope will greatly extend that of existing X-ray observatories. A specific optical bench is one of the three main components of the telescope. In addition to a platform with instruments and a mirror module, the optical bench has a telescopic design and is equipped with 1062 silicon optics.

Optical bench in hybrid manufacturing

The Fraunhofer-Institut für Werkstoff- und Strahltechnik IWS produced the optical bench by means of a hybrid manufacturing strategy combining laser powder buildup welding and precision cutting. This approach is one of the main research topics of the Hybrid Manufacturing working team employed at the "Additive Manufacturing Center Dresden" (AMCD). This group particularly deals with the combined application of innovative manufacturing strategies. Dr. Johannes Gumpinger, the head development engineer of the European Space Agency ESA, explains the significance of this project: "For the development of future satellites and carrier rockets, we are constantly searching for manufacturing processes that offer more degrees of freedom in design, increased efficiency, and reduced costs and delivery times. The fulfillment of these requirements has just been established by the 'Advanced Manufacturing Program'

Additive manufacturing of the optical bench

Robots shape the optical bench layer by layer up to a maximum height of 300 millimeters. Only the robot's radius of action makes it possible to manufacture this large-sized part.

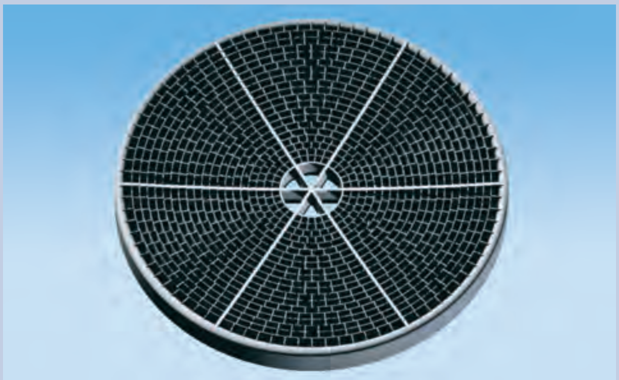

Illustration of a telescoping optical bench (diameter: 3 meter; height: 30 centimeter). The engineers installed silicon pore optics into each of the 1077 pockets (SPO).

at ESA. Additive Manufacturing complies with the criteria mentioned above and thus is regarded as an extraordinarily promising fabrication method." The technology has the potential to revolutionize not only the design of single components, but also, in the near term, even entire space shuttles. The ESA studies additive manufacturing techniques not only for small to medium-sized parts, but also for those up to several meters in size. The optical bench, which is essential for the ATHENA mission, is 30 centimeters high and has a 3-meter diameter. As a result, the choice of the fabrication technology is clearly limited. Gumpinger adds: "The robot-based laser buildup powder welding developed at Fraunhofer IWS, in combination with precision milling, belongs to the group of additive manufacturing techniques, and we see it as extremely promising to realize the project."

The goal in sight

Hybrid additive manufacturing of a complex large-sized part is extremely challenging in terms of production engineering. In intensive analysis, the team first evaluated the high-performance material used, the required geometric precision, and the necessary productivity in combination and derived a customized manufacturing cell. This cell unites the latest systems engineering from additive laser buildup welding, high-performance cutting, tactile and optical metrology, as well as smart process monitoring and control. A handling system linking two high-precision multi-axis robots with an NC rotary table with a diameter of 3.4 meters functions as the interface. During the implementation of the hybrid manufacturing system, the researchers combined the additive laser powder buildup technique with cryogenic high-performance cutting in one system for the first time. This enabled the intermediate milling of the component – which is essential for the process flow – without contaminating the surface. This approach makes use of maximal variety in design and the opportunities for functional integration in an entirely new way. Thanks to this development, the IWS researchers contributed to making this ambitious project reality. The next step is to execute a series of comprehensive tests to determine the material properties.

1 Illustration showing the ESA Athena mission.

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