# DEVELOPING A NEW BOOSTER


Engineering large CFRP components requires high precision in the heat treatment temperature controls to ensure the finished parts have the correct material properties

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Ariane 6 is the new launcher from the European Space Agency (ESA); its first launch is scheduled for 2020. The ESA collaborated with MT Aerospace and its partner, the German Aerospace Center (DLR), to develop the solid fuel booster. DLR used an annealing furnace from Vötsch Technik to anneal the large components. This furnace offers high temperature precision and therefore guarantees the required reliability of the process.

## ECONOMIC REQUIREMENTS

Ariane 6 is equipped with up to four boosters, which, as solid fuel tanks, are each filled with 135 metric tons of fuel. Until now, the boosters have been made of steel, which had a couple of drawbacks. For one, it was relatively heavy; and secondly, its production was complex and expensive. To avoid these drawbacks, the new boosters are being made of carbon-fiber reinforced polymer (CFRP), achieving excellent material properties in a simplified process with considerably reduced process costs. CRFP components are much lighter than steel components and therefore they increase the rocket's possible payload, which, in turn, improves the economic efficiency of each flight. The Vega-C launcher, which will use the booster as the main drive, also reaps the benefits of the new Ariane booster.

## MATERIAL PROPERTIES

On the one hand, the material properties of composite materials depend upon the selection and quality of the components. For this reason, carbon fibers and resin matrix are tailored exactly to the booster's requirements. On the other hand, the precise observation of the defined process parameters, in particular temperature control in the furnace, plays a crucial role in the quality of the component. In order to check the booster's production process, the booster shell was produced in advance at its original diameter – but only half the length. This size was sufficient for the developers to be able to intensively examine the production process and the material properties.

## OPTIMUM PRODUCT QUALITY

It is produced using a dry wrap procedure, in which dry carbon fibers are wrapped around a pin. Then, an infusion installation is fixed around the component and vacuum-drawn in order to ensure the resin flow in the component and to prevent air pockets. The resin matrix is transported from outside into the furnace via infusion tubes in the side openings on the furnace wall. It is infused in the component at the defined temperature in the furnace. The highly fluid resin inherently follows the pull of gravity; however, the booster must have an even wall thickness and therefore needs the even distribution of resin all around. This is solved by using a special rotation device in the furnace. It rotates the booster evenly and in doing so prevents the resin from running downward. For this, an axle is fed from outside through the furnace door that connects a motor to the rotation device. For the hardening process, the temperature is increased from the infusion temperature up to the hardening temperature using a predefined temperature ramp. The precisely defined heat with a temperature precision of ±2K ensures that the crosslinking occurs exactly as required and planned.

Clemens Schmidt-Eisenlohr, research associate at DLR, explains, "The huge size

**1 //** The tempering and curing oven for producing the booster sections of the Ariane 6 rocket

*(Vötsch Industrietechnik)*

of the component made the special application a real challenge. Vötsch Technik took on this challenge with dedication, designing the furnace controls so that the temperature distribution conformed with the requirements, even in the end areas of the furnace, which was full to maximum capacity."

## PROVEN FURNACE TECHNOLOGY

The used VTU 500/450/850 hardening furnace had interior dimensions of (WxHxD) 5,000 x 4,500 x 8,500mm (16.4 x 14.8 x 27.9ft) and an interior volume of more than $190m^3$ ($6,710ft^3$). The furnace works using particularly powerful fans. They ensure a high circulating air output, transport the heat quickly and evenly to the product, and enable high heating rates. The system is controlled using a touchpanel via the simple-to-operate Weiss Technik 'S!MPAC' controller. To meet the special requirements of DLR, the furnace was equipped with a series of special specifications. Alongside the rotation device, these specifications include the side feedthroughs that make it possible to transport resin from outside into the furnace. Products are fed into the furnace at ground level and without carriages or other equipment. That provides clear benefits, especially during development, and allows for more component flexibility in handling.

Björn Wieler, system engineer at MT Aerospace, adds, "In research and development projects, there are often special requirements. Existing technology has to be quickly adapted or modified. Vötsch Technik met all the requirements in the shortest time and to our great satisfaction, so that we were able to produce the boosters as we wanted."

The ESA coordinates European space activities – including overseeing the design and construction of the new Ariane 6 launcher. The agency commissioned aerospace technology specialist MT Aerospace to build the new booster. The company is a long-standing development partner of the Augsburg, Bavaria-based German Aerospace Center – Center for Lightweight-Production-Technology (DLR-ZLP).

The large, versatile furnace modified for the Ariane booster and described here is one of a number of furnaces in operation at the DLR. Not only is it used for the Ariane project, but it has also already proven its worth in other, extremely varied projects featuring large-dimension components.\\

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