

Industry 4.0: Roxor shot blast technology for ESA's European Ariane 6 space program

Spherical Components Formed by Shot Peening

Starting in 2019, Freymatic, MT-Aerospace and other partners have developed and put into production a new, innovative system that revolutionises the peen forming process, and this system has demonstrated its production worthiness for one year already. Despite several technical challenges and a demanding development schedule, all the major requirements for process reliability and performance have been met or exceeded.

MT Aerospace

in Augsburg manufactures, among other things, the fuel tanks for ESA's European Ariane 6 space program and for other space programs. The dome segments, which form the lid and base of the otherwise cylindrical tanks, are the core of the production technology. Each dome segment is made up of several panels welded together, the spherical surfaces of which must be dimensionally accurate and free of cracks and residual stresses prior to welding to withstand the high stresses during the short flight into space. MT-Aerospace decided to produce the dome segments in-house, from Ariane 6 onwards. Freymatic was chosen as one of the leading partners to achieve this goal.

Peen forming

is considered the supreme discipline of blasting technology, because over-blasting cannot be corrected. This is particularly true for spherical part surfaces. Critical process parameters such as flow rate, process pressure, ball speed and nozzle guidance along the part must be always be maintained within a range of < 2%.

As in the forming process, peening only takes place at certain points, it is necessary to move the shot stream away from the part surface within 0.1 sec and to move it back in again just as quickly. Furthermore, ball breakage or contamination can lead to irreparable defects in the part. Therefore, bad grains must be immediately and permanently

In the Spotlight:

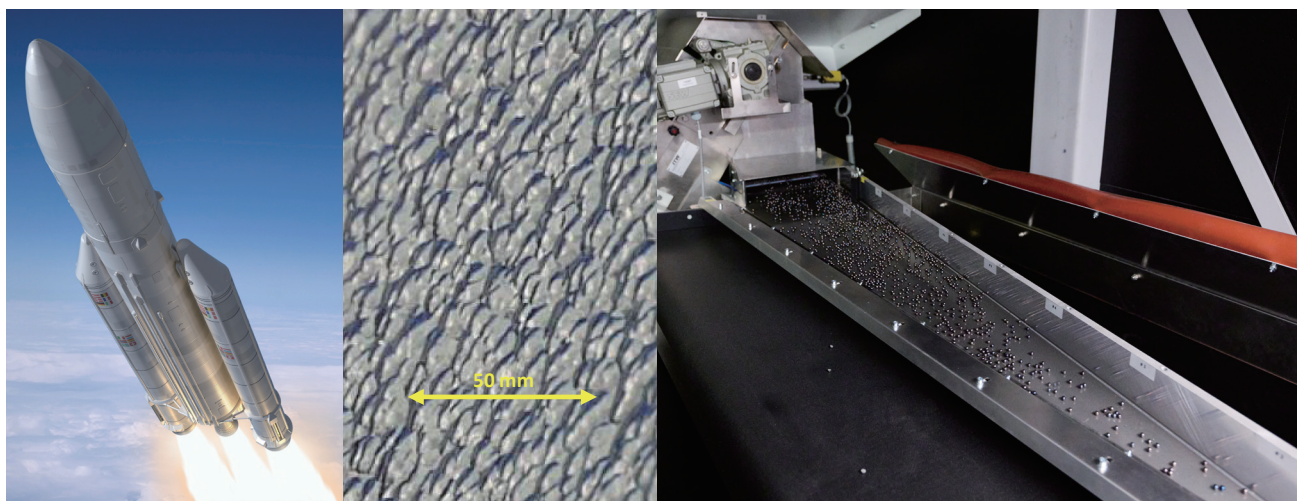
Roxor shot blast machines, manufactured by Freymatic AG, have proven themselves in the aerospace industry for the most demanding applications. The control of abrasive dosage is unsurpassed in terms of both flow range and dosage accuracy. With automatic tool change and in-line measurement, we have implemented a fully automated blasting process. Automation is continuous from loading, through quality control, to part unloading.

Freymatic also performs retrofits on existing shot peening machines, especially machines originally supplied by Baiker Freymatic and TBM Automation enjoy a close partnership for decades, bringing about many successful automation implementations.

removed from the process circuit before the part can be shot again.

Iterative manufacturing process

Parts must be handled with extreme care at every stage of the process because even the slightest contamination on the part will result in costly cleaning operations, while the smallest damage, such as notches, will render the part unusable. The peening process in the



Dome segments are among the most highly stressed parts of the Ariane 6 rocket. Absolutely homogeneous and defect-free surfaces are essential and they require reliable and efficient inline separation of bad grains in the shot blast media



No touching of critical part zones thanks to automated transport and measurement processes

cabinet is carried out in several dozen operations on both the concave and convex sides of the part, and different ball diameters can be used in the process. Between peening operations, inline shape measurements are repeatedly performed on the part to determine in real time that the process is within its control parameters. Complex al-

gorithms are used to automatically generate the peening programs for the subsequent operations based on the measurement results. Initially, the parts are peened over a large area, but as the shape is formed, only selective corrections are made. This means that the shutter must deflect the shot beam at short intervals and release it again

without any lateral impacts hitting the part surface at undesired points.

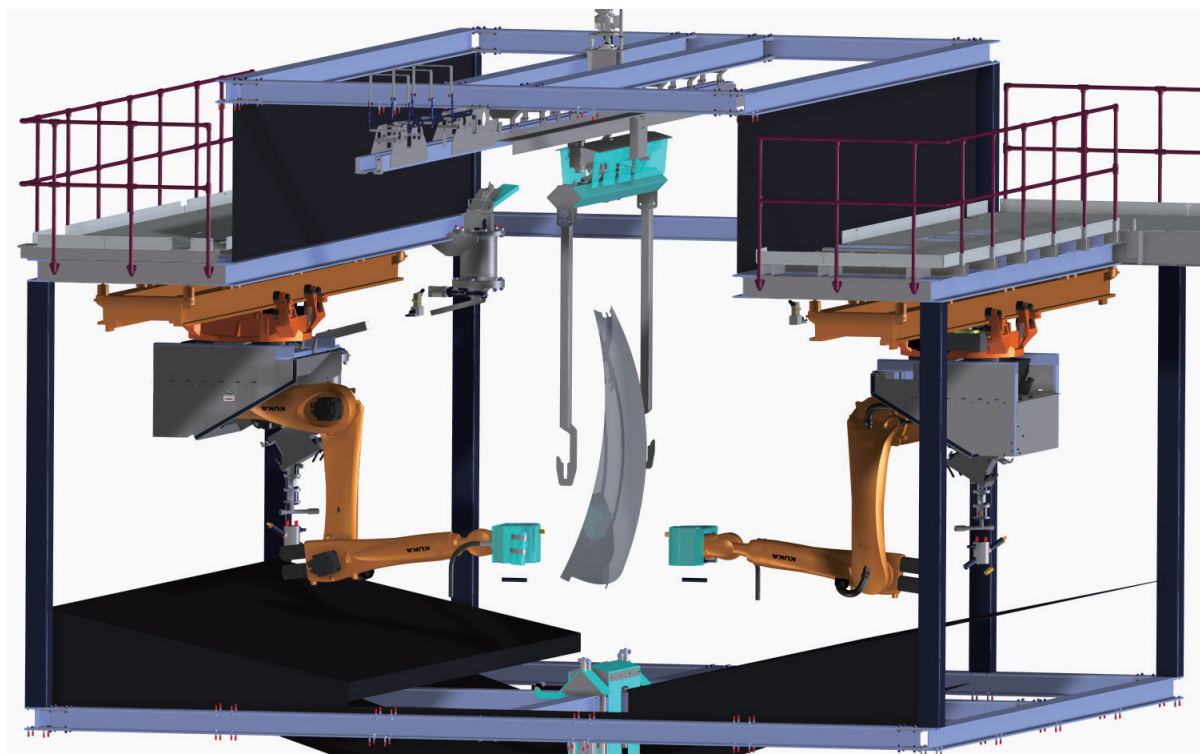
Innovative machine concept

The shot peening system had to be developed from scratch because there isn't an even remotely comparable template. This also applies to the core modules, which directly influence the process result.

The dosing system is designed to handle flow rates ranging 1 to 30 kg/min. Also, 5 different ball diameters of up to 10.0 mm can be processed without changeover with a reproducible variation of less than 2%. An application for the novel dosing principle has been submitted to the European Patent Office under No. 23150223.8.

Inline quality assurance and control

Between two peening operations, the ball diameter can be changed, and it must be possible to do this quickly and without time-consuming cabinet cleaning. Therefore, several ball diameters may flow simultaneously in the return flow. The newly developed ball diameter sorting module can simultaneously separate five different ball



Twin robot with integrated laser measurement and shutter

diameters at a rate of up to 60 kg/min. The inline bad grain separation process takes place via a cascade of separating devices, in which contaminants ranging from dust particles to a coarse contaminant such as a screw are systematically separated from the good grains. At the heart of this process is an inclined belt that reliably separates out ball fragments.

To be able topeen the parts, which can be up to 3.4 m x 2.0m on the convex side, the two robots must have a corresponding vertical reach and be able to be moved linearly in the horizontal direction, also used for refuelling. In this way, the suspended design of the robots has once again proven its worth. The robot head itself contains the blast nozzle incorporating rapid interruption by a shutter, and laser sensors for inline measurement of the parts.

Inline part measurement by laser scanning can be performed simultaneously on the concave and convex sides of the part. The beam process is suspended so as not to disturb the measurement unnecessarily.

The ball velocity at the exit of the nozzle is measured regularly to detect drift in the peening system at an early stage. In this regard, Sentenso's "Velocity Easy" is a world first.

Special workstations and transport devices were developed and manufactured by Freymatic for the loading

and unloading as well as the control measurements of the parts, and for the transport of the parts. The goal is that the parts to be launched into space should never be touched by the operators of the machine.

For offline part measurement, Freymatic installed two separate stations with lifting and swivelling functions. This measurement is usually performed as a final check of the peening process.

Project execution

The project commenced in 2019 and proceeded simultaneously on five different axes. MT Aerospace coordinated the activities between the main partners Freymatic, Sentenso and Nebumind, while Freymatic coordinated its subcontractors TBM, KUKA Robotics, Keller Lufttechnik and others.

The peening process was developed by MT Aerospace. For this purpose, SENTENSO was commissioned to build a test machine to be used to gain knowledge about the behaviour of the part under the influence of the peening process and how shape deviations are to be corrected. Nebumind GmbH used the knowledge gained from the test machine to implement sophisticated algorithms for the automatic generation of the peening programs.

Simultaneously with the above activities, Freymatic designed and built the

shot peening machine in close cooperation with MT Aerospace. Freymatic's focus was primarily on process control and overall part handling.

The Roxor KUMTA-102 shot peening machine is probably unique in the world in terms of functional scope, process complexity and performance. However, the technology applied can also be beneficial in simpler applications. With this project, Freymatic has once again demonstrated its role as a leading specialist machine builder, but without the partnership and constructive cooperation with MT Aerospace, this progress in shot peening technology would never have come about. At MT Aerospace, Industry 4.0 has arrived.

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