Replacing 5-axis machining of slender parts with additive manufacturing for the science industry

Egile
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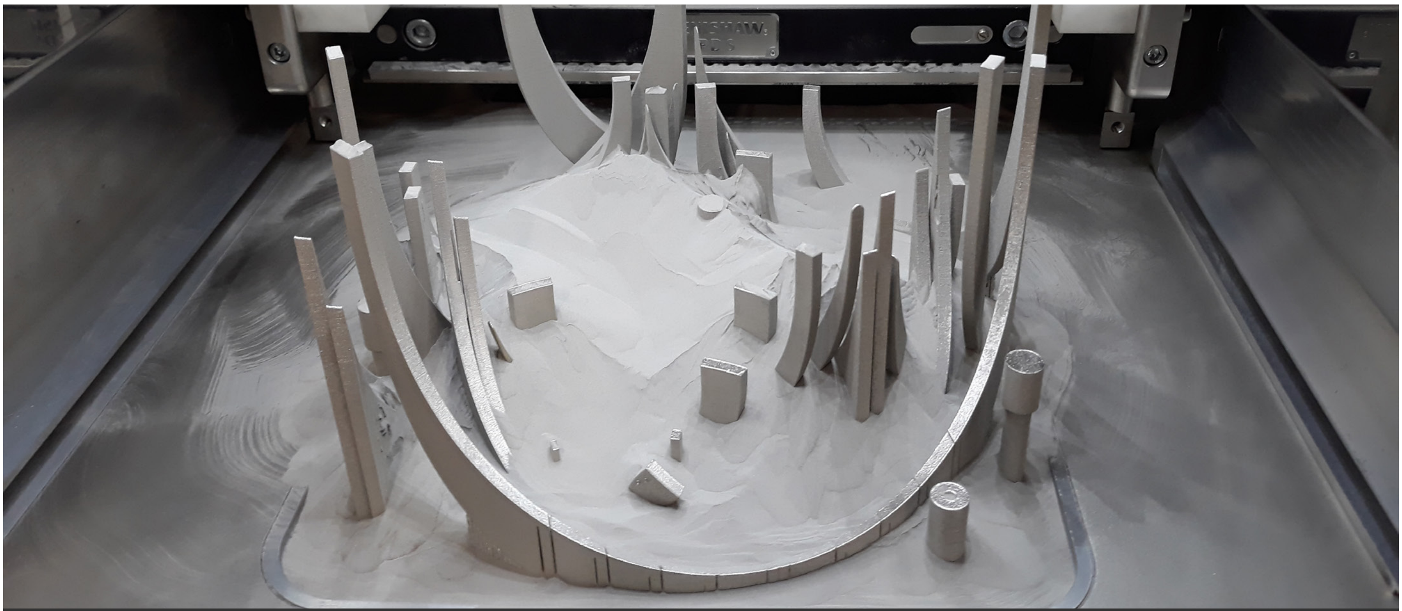

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Sector: Science
Challenge: Additive versus conventional manufacturing of a kit of 316L steel spacers for superconductor magnets. Technical and economic feasibility analysis.

Solution: The customer found a clear opportunity to improve processes and opted for additive manufacturing of these kits, which were previously manufactured by machining.

CHALLENGE

Egile additive manufacturing equipment was used in collaboration with a customer from the science sector to carry out a technical and economic analysis of additive manufacturing of a kit of parts that is currently manufactured by machining and other conventional processes.

These kits are part of high-performance magnets and each consist of approximately 25-30 parts of 316L stainless steel with complex shapes, each of which is different. These kits are manufactured by conventional machining (lathing and milling) after which the parts are processed by wire erosion to generate grooves that provide them with the flexibility required for their assembly. As regards demand, the customer needed short series, while the continuous improvements made to the design of these magnets involved small changes in the shapes of these kits.

The limitations of the conventional technologies used to manufacture these up until now are that:

- The variety in the shapes of each kit involves high cost in machine tools that has a significant impact on the cost of the parts, especially since the series are limited.
- Shape complexity increases manufacturing times since each part requires using a block of 316L steel and several machining processes.
- Long manufacturing times, constant tool changes and the need for two different processes (machining and wire erosion) increases the lead time.
- The economic repercussion of changes in manufacturing design (adjusting CNC programs and cost of new tools) sometimes prevents the customer from being able to improve their product and forces them to settle for obsolete designs.

SOLUTION

In this case, additive manufacturing seemed to be the most appropriate technology; specifically SLM (Selective Laser Melting) with powder bed fusion, due to the complex shapes and the few units to be manufactured:

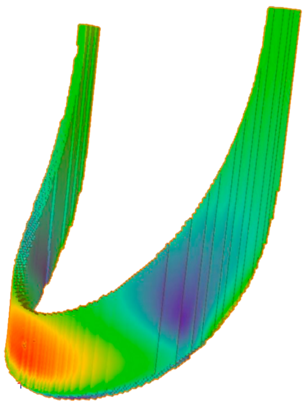
- The need for tooling disappears.
- The complex shapes do not cause an increase in manufacturing times.

• The changes in design of the parts do not involve an added cost, so the customer can immediately implement any product improvement they desire.

However, to assess the feasibility of changing the manufacturing process, in this case a precise analysis of the conditioning factors of additive manufacturing is required.

The first step was an analysis of the simulation of distortions during additive manufacturing. Significant distortions were observed on certain areas of the parts that would make final assembly impossible, which required understanding the causes and proposing a solution.

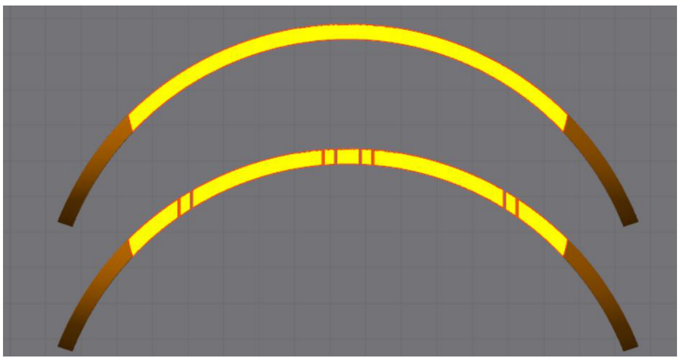
The distortions detected appeared on the area of the



part with the greatest mass and the largest section to be melted in each layer, due to the residual stress generated during the printing process.

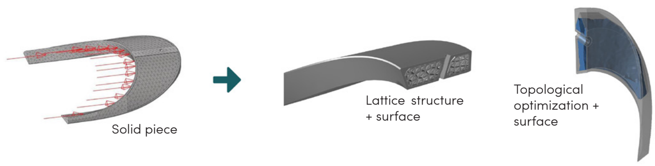
During the post-process analysis, our proposal to the customer was to integrate groove manufacturing in the same process used to print the parts (made by wire erosion up until now). By including the grooves in the solid material during the layer-by-layer printing process, the section to melt was not one but several small independent sections.

This resulted in a considerable reduction in accumulated



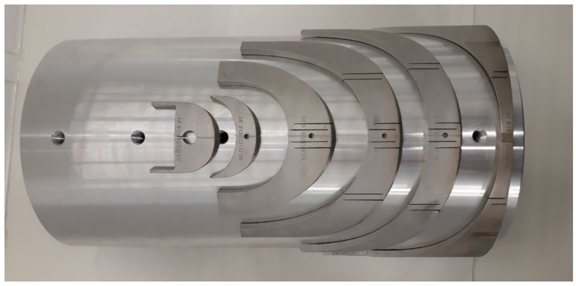
heat and therefore minimised the appearance of distortions in the shapes. By integrating the grooves in the additive manufacturing process, parts practically free of distortions have been obtained, thereby meeting customer requirements.

Lastly, the topological properties of the part have been optimised to reduce manufacturing times and the weight of the parts. This was done by defining the contour conditions, mechanical loads and available volume. The results were a weight reduction of 33% and 44%, applying lattice structure and topological optimisation strategies, respectively.



ADVANTAGES

The customer is very satisfied with the co-engineering work carried out with Egile. They have seen a clear opportunity to improve processes and have decided on additive manufacturing.



Egile's capability to manufacture comprehensive parts in SLM, including post-processes, has provided them with a complete understanding of the value chain and the ability to provide the customer with technological insight starting from design stages. In this case, the main advantages were as follows:

• Inclusion of the final shape in the printing process (including grooves made by wire erosion), which reduces the lead time and cost of part manufacture.

• Elimination of the need for tools and greater manufacturing flexibility means that the customer can immediately implement any design change or improvement in their product: shapes, topological optimisation, lattice structure, etc.