Serial production of combustor swirler for a Siemens Gas Turbine

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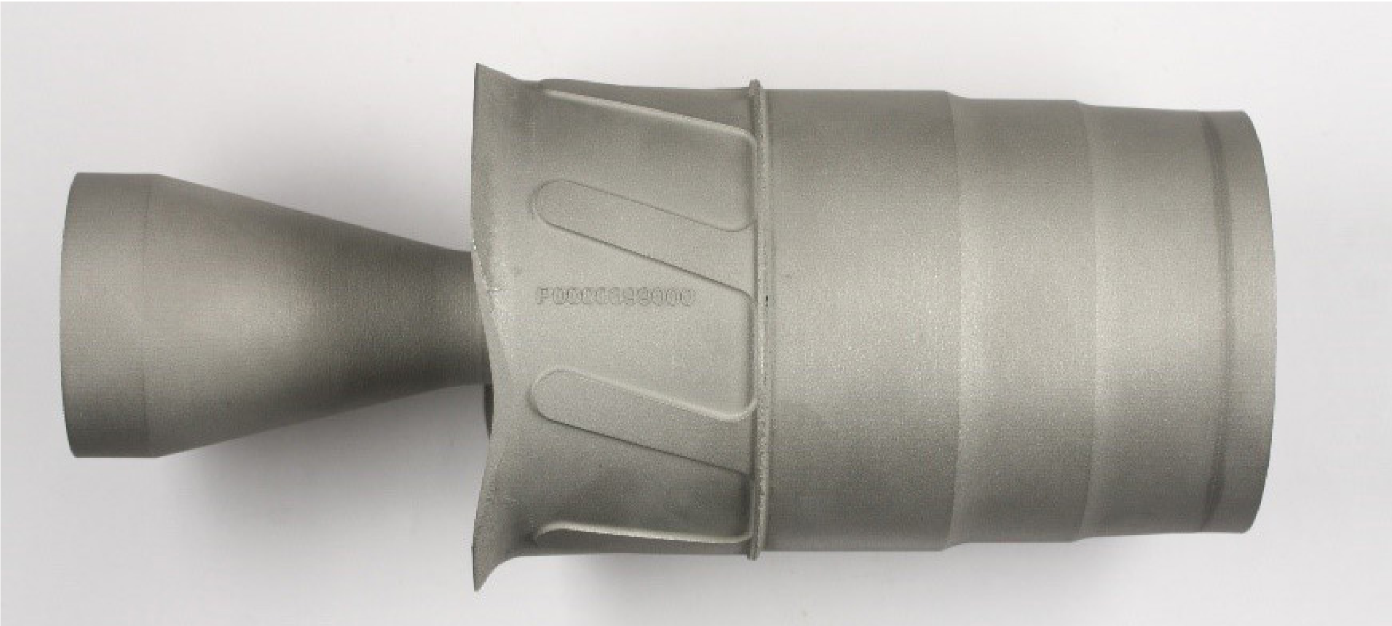

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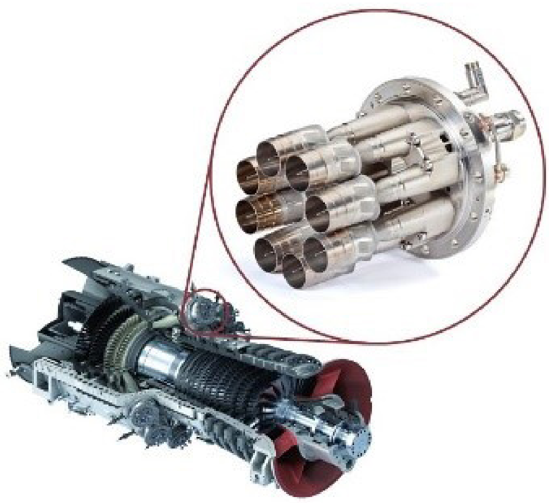
Sector: Energy
Challenge: Combustor parts are complex-design, high-temperature, performance-critical, long-lead items, critical to increase gas turbine performance and to meet environmental regulations.

Solution: Siemens redesigned a combustor´s swirler assembly by integrating components into a single AM design, and assured reliable serial production.

CHALLENGE

Proper air and fuel mixture is critical for a stable combustion. The swirler is responsible for mixing air and fuel prior to combustion. Swirlers consist of up to 10 cast and machined parts, that needs to be welded together in a quality-sensitive process. The current demand for swirlers for SGT5/6-8000H Siemens turbine fleet is of more than 1,000 units per year.

No standard AM process was available for this application. In order to meet high temperature requirements, a specific solution-strengthened Inconel alloy had to be developed. To assure reliable serial production, an integrated control over the entire process chain had to be defined and implemented. Powder requirements, printing parameters for the metal printer, heat treatment, post-processing and machining strategy, everything had to be specifically developed for this critical component of the gas turbine.



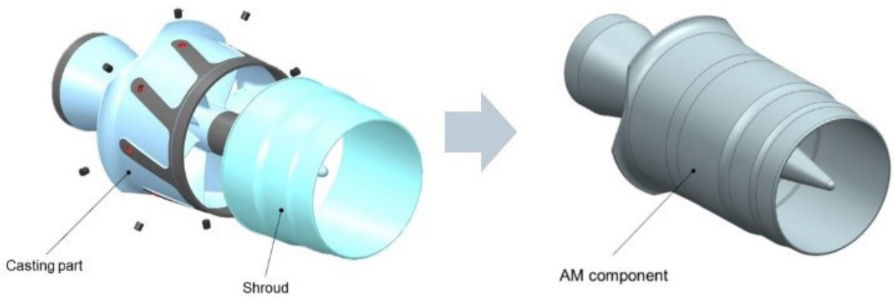
SOLUTION

Siemens´ engineers produced a design for the AM version of the swirler, integrating all parts of the current assembly into a single AM design. Redesign also allowed for enhanced performance of the combustor.

Time, cost, and performance are the main benefits AM designs can bring. In the case of the swirler, reduction of production time, reducing suppliers´ risk and improving part performance were the main drivers for selecting this component. Time savings were measured, tracked and improved in each step of the part's development until final design for serial production was reached. Automated depowdering to shorten manual post-processing time and ensuring complete depowdering is one good example. Next steps to improve manufacturing time, currently under implementation, will include e.g. automated powder handling systems.

In order to meet Siemens' stringent quality requirements, it took six months to qualify two AM metal printers (EOS M400-4, four lasers, powder bed fusion systems) for swirler production, currently at serial production. Two additional EOS M400-4 are currently in the qualification process.

Siemens employs in-house digital tools to track manufacturing parts during production. This includes Real Time Location Systems (RTLS) as well as digital twins of the swirler and the complete manufacturing system. Digital systems are connected to an Enterprise Resource Management system that allows real time monitoring of the production floor. Data are captured throughout the manufacturing process chain, starting from the original CAD models. Digital twins of the swirler are available at every stage, continuously updated when newly generated data produced by design and process changes are available. The digital management system is expected to include new functionalities, for example integrating the automatic powder management system, as soon as this process is fully operational. Digital management solutions are critical to assure quality requirements of the finished swirlers and a proper traceability of each individual part.



ADVANTAGES

In order to achieve a cost-efficient production, 16 swirlers are printed in a single build plate on an EOS M400-4. A significant time saving of more than 30%, just in the manufacturing stage, could be achieved by adapting printing parameters at selected areas of the part.

The conventional swirler design required significant machining and welding works to produce the final part, accounting for several hours of post-processing per each individual swirler. In the AM version post processing time is reduced more than 80%, many hand operations are replaced by automated processes, and quality records are improved.

Digitalization of the manufacturing process through the digital twin brings additional benefits. Starting with the CAD model, right after printing, swirlers are scanned, thus creating a second digital twin. This second digital twin is compared against the original model, looking for any deviations. When a significant deviation is found, the printing process of the next batch can be modified that way to correct deviations, and consequently produce more accurate parts. The second digital twin is also used to generate specific machining toolpaths for accurate machining when necessary. As a result, quality records are improved, and all part-specific records are stored for future use (e.g. repair after first operation cycle).

In summary, manufacturing time was significantly reduced and made completely in-house, avoiding delay risks originated by suppliers and reducing inventories required for burner manufacturing and for servicing units in operation. Quality records and traceability also improved, driven by the digitalization of the design and manufacturing shop. As a consequence of all these facts, overall part cost could also be improved. AM-designed swirlers provide additional performance features as well that helped improve gas turbine functionality.