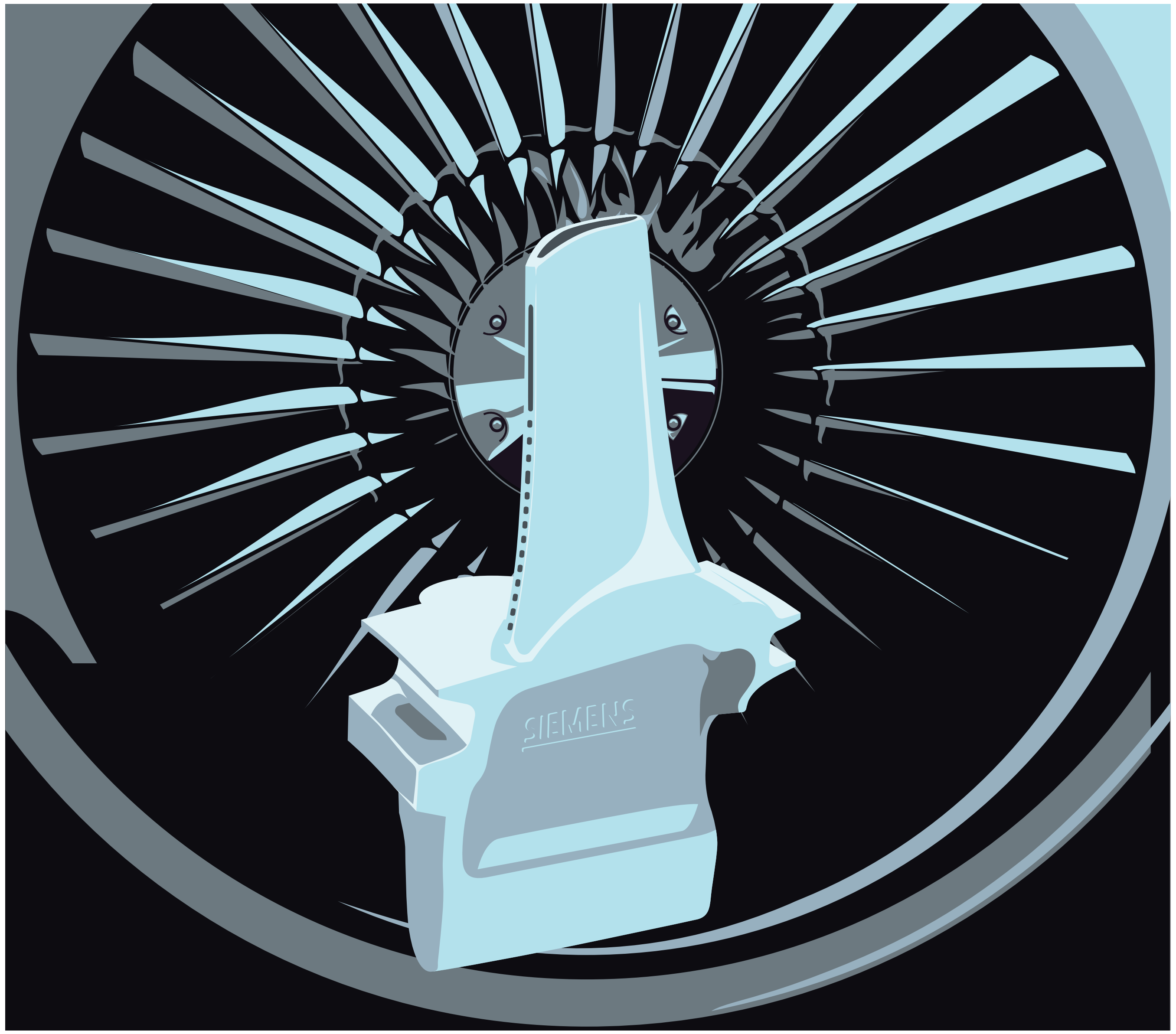
EMERGING TECHNOLOGY AWARDS



MANUFACTURING

ADDITIVE ADVANTAGE

Siemens prints a blade that survives inside a turbine.

STORY BY TOM GIBSON • ILLUSTRATION BY THOMAS ROMER

The rotating blades inside a gas turbine must stand up to intense heat and stresses. One small imperfection can cause the blade to rip apart—with catastrophic results. To achieve the necessary level of perfection, manufacturers have used investment casting, a complex, time-consuming, and costly procedure that requires building a mold for each blade.

Additive manufacturing could help speed blade development by eliminating casting, at least in the prototyping phase. One form of additive manufacturing, 3-D printing, has been used to build plastic models to show a design's fit and form.

Siemens has demonstrated the potential of 3-D printing by taking a printed gas turbine blade and successfully putting it through the paces of a turbine operating at high temperature, pressure, and centrifugal force.

Christoph Haberland, an engineer and expert in additive manufacturing for Siemens in Berlin, said, "It was a big success in proving that we can 3-D-print rotating parts that run on the machine. To our knowledge, nobody has tried this before."

The team behind the blade included project manager Jenny Nilsson, now a group manager for the design of additive manufacturing parts in Finspong, Sweden, as well as engineers at Material Solutions, a company Siemens later bought. "We started with an idea, and the vision was to print blades with different new designs and test and validate them in an engine," Nilsson said.

Team members developed better cooling designs to improve the gas turbine efficiency, designed the blade, and developed the whole manufacturing process to manufacture this type of component and geometry. "The whole purpose was to create an approach to rapid prototyping," Nilsson said.

Like all additive manufacturing, the team applied thin layers of material—one after the other—to build up a finished object. The main difference with Siemens' blade process was that layers were made of high-temperature-resistant, polycrystalline nickel-based superalloy powder, which was then heated and melted by a laser.

To prove the durability of the printed blades, they were installed in a 13-MW SGT-400-type industrial gas turbine at a Siemens test center for industrial gas turbines in Lincoln, U.K. At full power, turbine blades rotated at 13,600 rpm with a blade tip speed of 480 m/s and carried loads of 11 tons. The blades also had to withstand the heat from 1,250 °C gas moving through the turbine.

One advantage of 3-D printing turbine blades, Haberland said, was that "when you go with the conventional procedure, casting a design and testing it, this is a long lead time, and by using 3-D printing, we could reduce it by 75 percent." The team reduced the time from manufacturing the new design of a gas turbine blade to its validation from two years to two months.

Could 3-D printing go beyond prototyping and be used for production blades?

"The 3-D-printing processes and materials available today will not meet the long-term requirements of a blade," Haberland said. "However, we are developing new 3-D printing technologies, and we may end up being able to produce blades by 3-D printing in the future." ME

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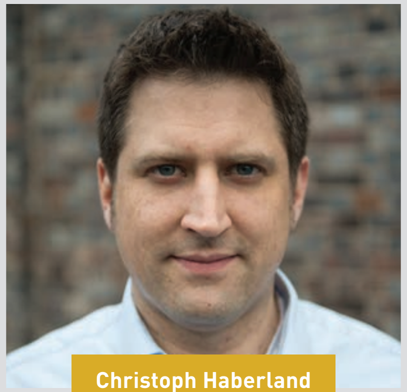
3-D PRINTED TURBINE BLADE

INNOVATORS Siemens. Christoph Haberland, Power and Gas Division; Jenny Nilsson, Additive Manufacturing Group.

INNOVATION A prototype blade made via additive manufacturing that can withstand the heat and stress found inside a gas turbine.

IMPACT Printed parts may cut the time to design new turbine blades by 75 percent.


Christoph Haberland


Jenny Nilsson

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