High-tech Repairs of Turbine Blades

Gas turbine blades are expensive. Each of them costs as much as a compact car and a gas turbine's rotor is equipped with hundreds of these blades. Because the heat and aggressive combustion gases inside the turbine corrode the blade material, Dr. Michael Ott from Siemens Energy has developed a technique for repairing damaged blades with the help of laser welding.

Turbine blades have to be extremely resilient. Depending on the turbine in question, the gas has a temperature of 1,100 to 1,400 degrees Celsius when it leaves the combustion chamber and comes into contact with the first rows of blades. Because the temperature of the gas is near the melting point of the blade material, the first rows of blades are covered with a protective ceramic coating and have coolant holes through which air wafts to form a cooling film. These measures reduce the heat on the blade surfaces to a more bearable 950 degrees Celsius. However, the blades located further back on the rotor don't have a protective coating. Although the temperatures there are somewhat lower than in the first few rows, the heat and the combustion gases still affect the blades and corrode their material. The blades are also damaged if the turbine is frequently turned on and off. Depending on whether a gas turbine continuously generates electricity (base load) or is only used to cover peaks in demand, the blades reach the end of their operating interval after 10,000 to 20,000 hours of operation, after which they have to be replaced and repaired. "That's why my colleagues and I looked for ways in which the blades can be quickly repaired in a standard process and under economically feasible conditions," explains Ott, who is a specialist in materials science.

Ever since he earned his doctor's degree in materials science at the University of Erlangen-Nuremberg, Ott has been studying nickel-based superalloys. Such materials are also used for laser powder cladding in order to fill in any cracks and indentations on the blades. "The material remains stable even when the metal is heated to 950 degrees, as happens in a turbine," says Ott. A disadvantage of the material is that it is extremely difficult to weld. In fact, a workpiece has to be heated to over 900 degrees to make welding possible. "It's very difficult to uniformly heat a blade so that you can begin welding," explains Ott. That's why he worked together with the Fraunhofer Institute for Laser Technology in Aachen to develop a technique for welding the material onto the blade at room temperature.

"The trick is to melt the material in very small processing steps," explains Ott. To do this, the laser head moves at a speed of 500 millimeters per minute across the blade. The cladding material welded onto the blade then cools off so quickly that no stresses arise that could cause strength-reducing defects. As a result, it can take an entire eight-hour shift to repair a blade. "Although this is a relatively long amount of time, the blade's value makes it worthwhile," explains Ott.

However, Ott is also experimenting with other welding additives for increasing component strength. “To boost the efficiency of gas turbines, we have to operate them at higher temperatures. But that’s only possible if we can create a material that can withstand such heat,” says Ott. In cooperation with the Fraunhofer Institute for Laser Technology, Ott and his colleagues are therefore continuing to forge ahead with research.

Ott has been working for Siemens since 1998. He initially studied ways to improve the casting of turbine blades and ensure their quality. As part of this effort, he also spent one-and-a-half years at a special foundry in the U.S., where Siemens makes some of its blades. For several years now, Ott has not only been specializing in laser welding and high-temperature soldering, but also in the development of repair techniques for hot-gas components. Ott has registered a total of 100 inventions, which have led to 93 individual patents in 71 IPR families. When he’s not working, Ott spends a lot of time with his wife and son. He likes to ride his bicycle and motorcycle, which he also repairs himself. “I enjoy doing all kinds of craft activities because you can quickly see the results,” he says. He also likes to read English crime novels in order to hone his foreign language skills.