Advanced Industrial Gas Turbine Repair Alternative

MATT LAU
SULZER TURBO-MACHINERY SERVICES

Firing temperatures of gas turbines have been increased over the years, as part of the drive to improve efficiency. This increase has required the development of more complex hot-section components with intricate cooling schemes, coupled with improved thermal barrier coatings and advanced materials. Sulzer Turbomachinery Services has the know-how and experience to repair these advanced-technology components.

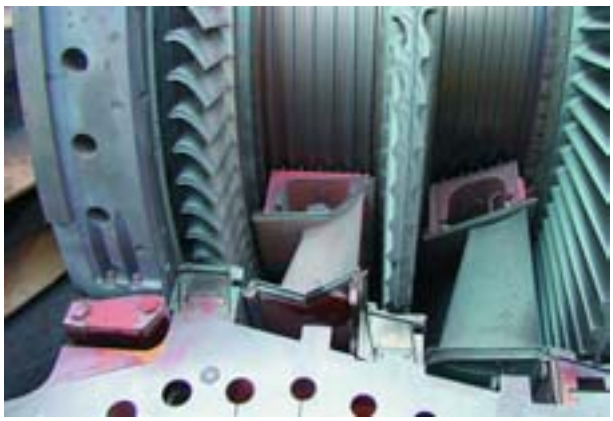
The sophisticated designs of the advanced-technology components used in the hot sections of the F-technology generation, or third generation, of gas turbines have presented significant challenges to the aftermarket repair sector. Many of the standard repair processes could not be applied to such complex designs. New welding techniques, coating materials, inspection procedures, and tooling were necessary to properly restore the components to a safe and serviceable condition. In 2001, Sulzer Turbomachinery Services began to partner with end-user customers of F-technology machines, with an initial focus on repairing those components that present the lowest level of risk. New and low-operating-hour

1 These fixtures simulate the transition piece fit-up in the turbine, thus ensuring repeatability and accuracy of transition piece repairs.

components were issued for inspection. Using coordinate measuring machines, radiography, and other techniques, detailed component drawings were produced and critical repair-oriented data was taken. Next, the materials were analyzed, using non-destructive methods, to verify the alloys and coatings used for each section of the components. Access was given to on-site F-technology machines, where specialized assembly tooling and procedures for on-site overhaul work could be developed and the critical field dimensions needed to ensure accurate component repair and tooling could be obtained. Once all this information had been collated and exhaustively checked, the necessary repair and coating methods were carefully developed to suit the specifics of each component type. Specialized tooling could then also be designed and made with a high level of precision to ensure repair repeatability and accurate installation in the field.

The progress in certain component categories is summarized below.

2 Parent metal bonding is used to restore wall thickness and repair minor cracking on the nozzles.



Combustion Components

The combustion section includes components such as fuel nozzles, cowl caps, combustion liners, transition pieces, and flow sleeves. Sulzer Turbomachinery Services focused first on the development of repair processes for these components. A robust new test stand and large mass-flow plenum was commissioned to inspect and flow-test the fuel nozzle assemblies. Two 360° compressor-discharge case/first-stage nozzle fixtures (Fig. 1) were procured for two different models of F-technology gas turbines to simulate the transition piece fit-up in the turbine. This ensured the repeatability and accuracy of the transition piece repairs.

Hot-Section Stationary Components

Sulzer Turbomachinery Services has successfully refurbished multiple sets of first-, second-, and third-stage shroud assemblies, as well as the second-stage nozzle assemblies. Currently, Sulzer Turbomachinery Services is pursuing the repair of first-stage nozzles for additional models of F-technology gas turbines. The development of repair procedures for these hot-section stationary components followed the same conservative and careful methodology as described above for the combustion components.

Second-stage nozzles composed of the nickel-based alloy GTD 222 have been successfully refurbished. The diffused aluminide coating on the external and internal surfaces of the gas path had to be removed by specialized chemical stripping processes. Full di-

mensional and non-destructive inspections were performed, and a customized repair work scope was developed for the nozzle assembly, with weld repair being the primary method of dimensional restoration. Sulzer Turbomachinery Services' advanced braze process, known as parent metal bonding, or PMB, is also used to restore wall thickness and repair areas where there is minor cracking. PMB uses a mixture of select alloy powders and proprietary binder combinations designed to closely approximate the microstructure and composition of the parent alloy (Fig. 2). PMB is applied to the prepared surface of the nozzle segment and then processed in a vacuum furnace. Finally, when the nozzle segments have been repaired and heat treat rejuvenated, internal and external aluminide coatings are reapplied to the gas path. The nozzle segments are then assembled and checked in a turbine case simulating fixture to assure their correct dimensional positioning in the field (Fig. 3).

Hot Section Rotating Components

Sulzer Turbomachinery Services made a significant investment in a highly flexible five-axis laser welding center. Application of this technique leads to a smaller heat-affected zone, limited dilution of the substrate with weld filler material, lower welding stresses, and elimination of component distortion. Sulzer Turbomachinery Services has already developed this technique for the repair of traditional technology rotor blades to a level that non-laser methods could not achieve; for example, by restoring rotor blade wall thickness with laser weld repair and rebuilding rotor blade tips to near net shape by injecting superalloy powder into the liquid pool created by the laser beam on the substrate.

Moreover, several significant laser welding techniques have been developed and patented. These techniques open up new possibilities, such as the repair of cracks close to the roots of rotor blades that would otherwise have to be scrapped. In suitable areas of components, the grain structure and orientation of directionally solidified and single-crystal base materials is continued in the weld deposit.

Further investment in sophisticated laser welding and digital x-ray equipment is in progress, and Sulzer Turbomachinery Services is continually developing the use of state-of-the-art techniques for the repair of advanced-technology hot-section rotating components, in the firm belief that they will gain widespread acceptance among our customers.

In-House Coating Capabilities for Advanced-Technology Components

Sulzer Turbomachinery Services has developed in-house specialized coatings that meet or are superior to the coatings originally applied to advanced-technology components, in order to help them withstand the high temperatures they are exposed to. Specialized thermal barrier coatings (TBC) are robotically applied in-house to the combustion liners, transition pieces and first-stage nozzles. An abradable TBC, PXT-70, has also been created for use on the first-stage shroud assemblies. Another of the new coating developments is the XTR TBC (extreme temperature resistant TBC), which is a type of vertically fractured, compact coating that is especially designed for application on first-stage advance technology turbine buckets. Investment in additional advanced robotic thermal-spray systems is now being planned.

The Future of New Technology Repairs

Partnering with end users has made it possible to develop comprehensive repair technologies and procedures—ranging from field services to hot section component and rotor repair, through to reassembly—making Sulzer Turbomachinery Services an outstanding repair alternative for customers with F-technology gas turbines. ◀

3 After repair, heat treatment and coating, the second-stage nozzles are assembled in the turbine case simulator to ensure correct dimensional position in the field.

CONTACT

Sulzer Hickham Inc.
Matt Lau
11518 Old La Porte Rd.
La Porte, TX 77571
USA
Phone +1 (1)713-567 2871
Fax +1 (1)281-567 2831
matt.lau@sulzer.com