

Repairing Advanced Gas Turbines

Extending the Life of Turbines to Reduce Operating Costs

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The number of advanced gas turbines installed is increasing rapidly due to rising fuel costs and environmental regulations. Higher operating temperatures and mechanical stresses are creating the need for the use of advanced-technology components and refurbishment processes. Sulzer Elbar, a Sulzer Turbo Services company, has therefore developed innovative repair methods for modern gas turbines that extend the operational life of the machines.

▶ Recent developments and research have resulted in the production of advanced gas turbines with high efficiency (over 60% in combined-cycle plants) and low levels of emissions. These improvements have primarily been achieved through higher operating temperatures as well as the use of advanced cooling techniques and new alloys developed to withstand higher temperatures.

The components of advanced gas turbines are subjected to large mechanical loads and severe environmental loads, including creep, thermo-mechanical fatigue, and hot corrosion. These are the main damage mechanisms that lead to the degeneration of hot-section components.

If the components' wall thickness is reduced by hot corrosion, excessive cracking due to thermal

strains, or other causes, conventional repair procedures may not be able to guarantee their reliability. Advanced refurbishment techniques are therefore needed to extend the components' service life. To limit the potential that damage will reoccur during the next turbine exposure, it is essential to analyze and determine the cause of damage and the predominant damage mechanisms.

In-House Research

The extension of a turbine's service life through the implementation of advanced refurbishment procedures significantly reduces operating costs. In general, refurbishment activities consist of the stripping and reapplication of the coating, the rebuilding of the geometry by welding, and the rejuvenation of the material condition through appropriate heat treatments. Advanced refurbishment procedures also include

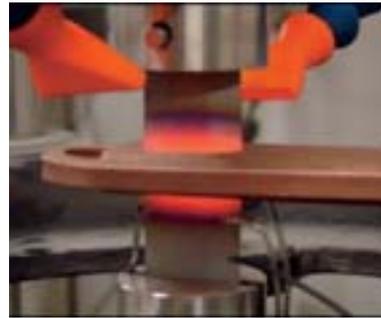
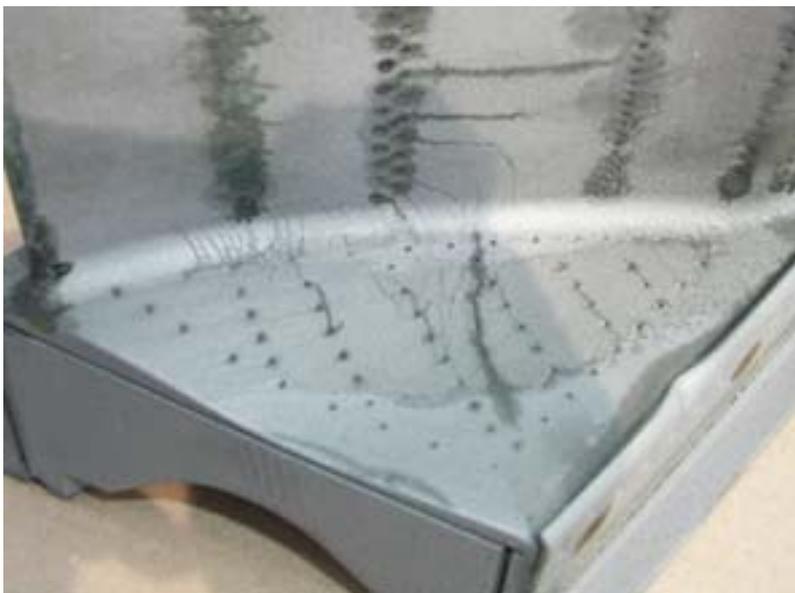
changes in materials, coatings, or designs, which should reduce the risks of failure or the reoccurrence of damage. Dedicated in-house research and test methods are essential in order to successfully develop and implement advanced refurbishment techniques.

Advanced Vane Repair

In many advanced gas turbines, the service life of hot-section components is reduced as a result of high operational temperatures and stresses. Critical components, such as first-stage rotating and stationary components, often display extensive operational degradation (Fig. 1). In such cases, a detailed damage assessment—comprising a series of in-depth metallurgical inspections—helps to determine the cause of damage.

The combination of thermal strains, the brittle MCrAlY overlay coating originally applied, and the restricted properties of the base

1 Extensive cracking of a first-stage turbine vane after 16,000 operating hours as a result of unequal temperature distribution in the vane airfoil. Sulzer Elbar has developed advanced procedures to repair damaged gas turbine components.



2 Test stand for the selection of nickel-base superalloys with the best LCF properties.

alloy leads to extensive cracking even with a limited number of starts and stops. Conventional refurbishment techniques are inadequate and result in the rejection of these components—with financial consequences for the owner or operator.

Sulzer Elbar has developed effective refurbishment procedures that



3 Results of LCF analysis of nickel-base superalloys: the growth of cracks during experiments.

enable severely damaged components to be fully restored by reducing thermal strains and applying higher-grade materials with thermo-mechanical properties that are superior to those of the original material.

All advanced refurbishment procedures are subject to full testing and quality assurance procedures prior to the actual application. In some cases, a dedicated test stand is developed to verify the refurbishment process under operational start/stop conditions.

Improved Fatigue Resistance

Sulzer Elbar has designed a test stand for the selection of nickel-base superalloys with the best low-cycle fatigue (LCF) properties (Fig. 2). In this test, a tapered test piece is repeatedly heated and

4 Custom-made replacement leading edge joined by laser welding.



cooled in quick succession. The temperature gradients result in thermal strains. After a specific number of thermal cycles, the material starts to crack. The crack length as a function of the number of cycles is recorded for each base material. The selected patch clearly displays superior LCF resistance compared with the vane base material (Fig. 3).

Replacement of the Original Material

In certain cases, the degraded vane material is beyond the technical possibilities of restoration and the entire leading edge must therefore be replaced (Fig. 4). Custom-made replacement leading edges are manufactured and joined by laser

5 Thermoshock tests show the integrity of the thermal barrier coatings.



fusion welding. Sulzer Elbar has extensive in-house capabilities in the field of laser fusion welding—a technology which results in a high-quality, crack-free joint with superior mechanical properties and limited distortion.

Coating Extends Service Life

To further extend the operational life of the turbine after refurbishment, a dedicated and improved coating scheme—comprising a thermal barrier top coating (TBC)—limits the magnitude of and variations in thermal strains over the entire vane. LCF resistance is significantly improved as a result. In addition, dedicated in-house testing is carried out to ensure the adhesion of the coating (Fig. 5).

Vanes that have been refurbished using advanced refurbishment procedures are installed in the gas turbine and put into operation. Materials analyses performed after a full operational cycle for a specific project reveal the improvement in performance (Fig. 6).

Repairs Add Value

Sulzer Elbar offers many similar types of advanced component refurbishment solutions, thus demonstrating that a combination of expertise in material science, skilled workmanship, and highly developed in-house processes are prerequisites for the reliable and cost-effective extension of the life of a component. Repairs that improve the machine create significant added value and reduce the cost of ownership for the owners and operators of gas turbines, steam turbines, and compressors.



6 The coating microstructure shows no indications of damage after a full operational cycle.

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