Repaired – Not Scrapped

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A large land-based gas turbine operating in utility service in Southeast Asia suffered an unscheduled forced outage due to severe damage of several turbine parts. Sulzer Turbomachinery Services companies – Sulzer Hickham Indonesia and Sulzer Elbar – manufactured replacement components and carried out all repairs in order to get the unit back into service in the shortest possible period of time.

An electric utility company in Southeast Asia has been operating a big gas turbine in a combined-cycle configuration. The unit is natural-gas-fired and spins at 3000 rpm, producing 90 MW through just the gas turbine alone. The massive 55-ton rotor has a maximum diameter of almost 4 m and a length of almost 10 m (Fig. 1). In January 2002, the gas turbine failed.

A major overhaul and upgrade had been performed on the gas turbine approximately 18 months prior to the outage. It was determined by the equipment owners that a newly designed and installed seal had failed during operation and entered the hot-gas stream, causing damage to the turbine rotating blades and stationary vanes. Additionally, five rows of compressor blades and the drive end shaft were damaged as a result of a secondary failure.

A preliminary inspection conducted by the OEM left the operator with the feeling that a repair to the rotor was impractical because of the extent of the shaft bending and the necessity to replace the rotating turbine blades and sets of compressor blades. At the time, it was determined that a repair would be impractical because of its length of time. The utility company was faced with two very unfavorable choices: purchase a replacement rotor at very high cost or repair the rotor with a very long outage period.

Lower Costs and Shorter Outage

Sulzer Hickham Indonesia was contacted by the equipment owners and asked if there were any other options. An on-site inspection revealed that some bending had occurred, but that it was within repairable limits.

The inspection data and analysis results were presented to the utility for review and assessment complete with a matrix of repair options, favoring minimal component replacement and maximum component repair – all in the shortest possible time. Since the utility had never before performed a major rotor repair with anyone but an OEM, the Sulzer Turbomachinery Services companies were required to undergo a rigorous due-diligence process. The facilities and associates on three continents were required to prove, beyond a shadow of doubt, that they were technically sound, fully capable of performing the work, and able to co-ordinate activities in order to guarantee success.

Specialized Repair Techniques

Sulzer Hickham Indonesia received the repair contract in May 2002. It called for an extremely short, 14-week total schedule. After allocation of time for transportation and custom clearance, this left only 10 weeks in which to actually complete all the work. A dedicated project manager was assigned by Sulzer Hickham Indonesia to provide management, co-ordination, and control of all the activities taking place around the world in support of the contract.

Turbine blades and vanes were dispatched directly from the site to Sulzer Elbar in the Netherlands for detailed inspections and repair. Their use of highly sophisticated analysis methods and repair techniques (see STR 4/2001, p. 4) allowed for the re-use of over 80% of the parts that had originally been determined to be scrap. After repair, all of the rows of rotating blades were coated, using materials and processes custom-matched to the specific operating environment of each blade row in the gas turbine.

Once the gas turbine rotor was received at the Sulzer Hickham In-

1 Rotor of a huge gas turbine which could be repaired by Sulzer Turbomachinery Services after a severe outage. The gas turbine is used in a combined-cycle power plant. The repair was faster and cheaper than a replacement.

2 The gas turbine rotor is being machined in a large lathe.

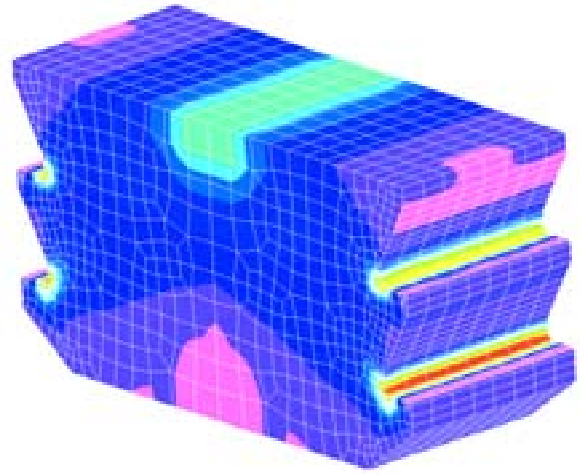
donesia service facility (Fig. 2), complete inspections were undertaken to more fully document the extents of damage. They confirmed the shaft deflections discovered in the field. A detailed, iterative repair process was designed, incorporating the use of thermal and mechanical stress relief and shaft straightening techniques. Emphasis was placed on methodologies to correct the shaft deflection without dimensional alteration or compromise of mechanical integrity, in order to minimize the requirement for modifying other components in the system to a non-standard configuration. The process was implemented, and the results were highly satisfactory, achieving "like new" tolerances on the shaft.
Since the rotor is constructed by welding several large sections together, there was a significant level of concern regarding the integrity of the welds after the failure. The rotor welds were inspected via sophisticated straight and angle beam ultrasonic methods. All welds were found to be in a sound condition, and the rotor was certified as fit for service.

Component Manufacture

As a part of the contract, Sulzer Hickham Indonesia and Sulzer Elbar were required to produce partial sets of compressor blades and full sets of turbine rotating blade and stationary vane-locking hardware. The compressor blades were subjected to a rigorous reverse engineering and design review process that included finite-element analysis (Fig. 3) for optimization of dimensions and tolerances in the highly stressed root areas. Additionally, five rows of the compressor blades were coated with phosphate-bonded aluminum to reduce friction and offer long-term corrosion and erosion protection.
The locking hardware consisted of almost 6000 individual pieces that needed to be manufactured to extremely tight tolerances. Sulzer Hickham Indonesia and Sulzer Elbar had to go through extraordinary measures to reverse-engineer, analyze, design tooling and perform quality checks to ensure that acceptable components were delivered in the proper time frame.

Successful Start-up

A progressive delivery program was developed to allow for the completion and installation of all the manufactured and repaired components in a co-ordinated fashion, minimizing delays. Afterwards, the rotor was low-speed balanced in the shop.
Working together with the field crew from the utility, Sulzer Hickham and Sulzer Elbar personnel were on site when needed to answer questions, provide direction, and solve problems during the reassembly period.
In September 2002, the unit was started up. On the first full-speed no-load run it achieved vibration levels of less than 20% of the unit alarm levels. Fully satisfied, the utility proceeded to connect the unit to the electrical grid, where it is currently operating as a key component in meeting the electricity needs of the nation. ◀



3 Finite-element analysis of a compressor blade root, enabling an improvement of dimensions.

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