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Casing repair adds years of service to vintage turbine

Many old fossil-fired units must operate on an as-needed basis. But cracking is inevitable. Here, rehabilitation of a turbine casing is described that required 25% of the downtime and less than 7% of the cost of replacing it

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Equipment rehabilitation has become a way of life at many powerplants. Where new units are not being added to the grid, inefficient older units must operate on an as-needed basis, which often means daily cycling. Cycling accelerates the natural component aging process. But this is less of a problem today because the engineering expertise has been developed to repair components instead of replacing them. A casing in point is a 60-MW 1949-vintage steam turbine on the Ohio Edison Co system.

Originally designed for base-load service, it was switched to cycling service in 1958. Normally, the unit does not operate on weekends and has experienced around 200 starts per year for the last 10 years. Cracking was first noted 30 years ago on the upper and lower outer shells. Mechanical stitching was used repeatedly for the next two decades to repair cracks and arrest their growth.

Despite this work, extensive cracking became apparent in 1978 in the lower shell, resulting in leakage from the nozzle chamber area through the first-stage inner gland and into the water seal area. The unit was able to operate with the help of intermittent repairs, but the steam leak became more severe. In 1989, the unit was shut down for a comprehensive inspection and repair.

Unique to this unit, however, was a design modification which occurred prior to 1960. For unspecified reasons, one of the partitions in the nozzle chamber area had been removed. The weakened condition contributed to the progression of cracking across the high-pressure and low-pressure dummy seal areas.

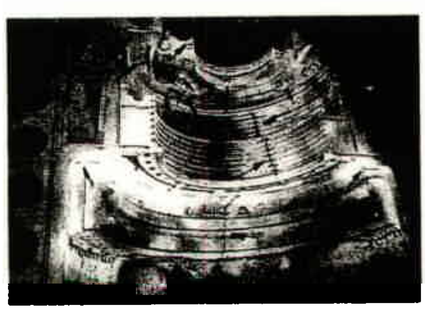
Fig 1 illustrates the various crack locations discovered following a liquid-penetrant examination. More sophisticated and more expensive evaluation techniques—such as finite-element or stress analyses—were not considered necessary for this repair.

Microstructural analysis (Fig 2) and scale-thickness measurements of a sample removed from a crack in the upper shell suggested the crack began 90,000 hours before the through-wall cracking—and steam leakage—was documented. The analysis also confirmed that cracking was caused by thermal fatigue associated with cyclic operation and mechanical stresses associated with cross-sections of uneven thickness. The latter condition resulted when the partition was removed.

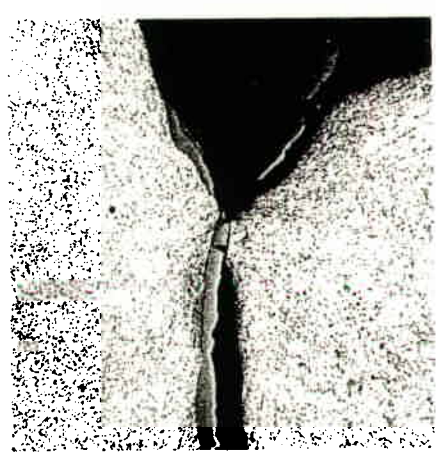
Objective of the repair program was to restore the unit for at least 15 additional years of service. It was known that operating characteristics of the unit would not change and thus could lead to additional cracking. But the unit had operated for at least 15 years prior to the development of significant cracking under those conditions so the additional service life expected of the repair program was considered achievable. Modifications to the nozzle-block area (Fig 3) were part of the repair program.

It is important to note that the repair of this unit, like any other, is a fluid procedure. Though a plan is formulated initially, it must be continuously modified as the actual parameters of the cracks become known. Lack of access may prevent the removal of a crack in its entirety. In other instances, too much metal would have to be removed to successfully repair a crack. Other constraints, such as the stresses inherent in the metal, unit design, and the applicability of welding techniques also influence whether removing a crack will be beneficial or detrimental.

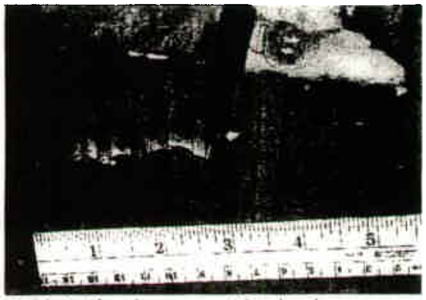
Crack removal was acomplished with either arc-air gouging or grinding, depending on the extent of cracking and its location. In areas where the mechanical stitching had not held, all stitches plus the cracks were removed. This increased the amount



1. Arrows highlight areas selected for crack removal and repair

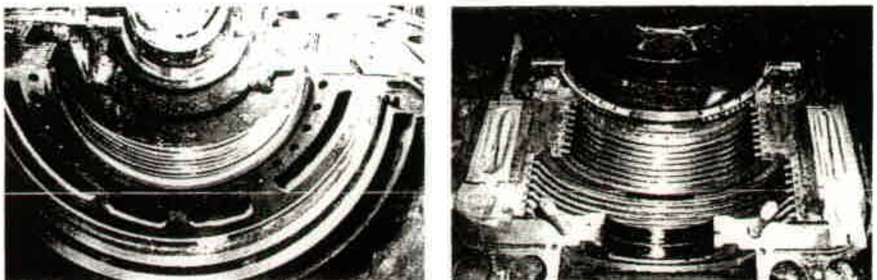


2. Microstructure analysis indicates when crack was initiated



3. **Distortion** is apparent in gland area where steam leakage occurred

4. **Lower casing** is shown after repair and addition of new partition in steam inlet area



5. **Final machined surface,** left, is shown for lower half of casing; new nozzle blocks are installed, right

of metal loss and became a factor in the repair program.

Preheating came next, performed with resistance heating elements. Although rosebud torches can be used for some localized repairs, it was not recommended or used here because it does not provide the even heat distribution essential to this type of repair. Continuous monitoring and control are also of paramount importance during the preheating stage. Once the desired temperature was achieved, welding was performed. Special welding techniques were followed which minimized distortion and residual stress formation. After welding, a specially developed stress-relief heat-treatment procedure was applied, necessary to minimize stresses associated with welding but also to correct the distortion in the gland area. The particular welding technique must be selected based on both casing design characteristics and the peculiarities of each crack.

Throughout the repair process (Fig 4), dimensional measurements were made to monitor axial and radial growth. Adjustments to the heat-treating and welding procedures were made accordingly.

Machining was done with both halves bolted together (Fig 5). The unit was reassembled and returned to service.

Since the repair was performed, the unit has operated for close to two years and has been subjected to numerous starts. No leakage has occurred. Repairs cost less than 7% that of the purchase price of a new casing. Lead time to replace the casing was estimated to be 18 to 24 months. Repairs took six months. Fifteen years of service are expected on the repaired unit without a through-wall steam leak, assuming it is exposed to the same operating conditions.

Edited by Jason Makansi