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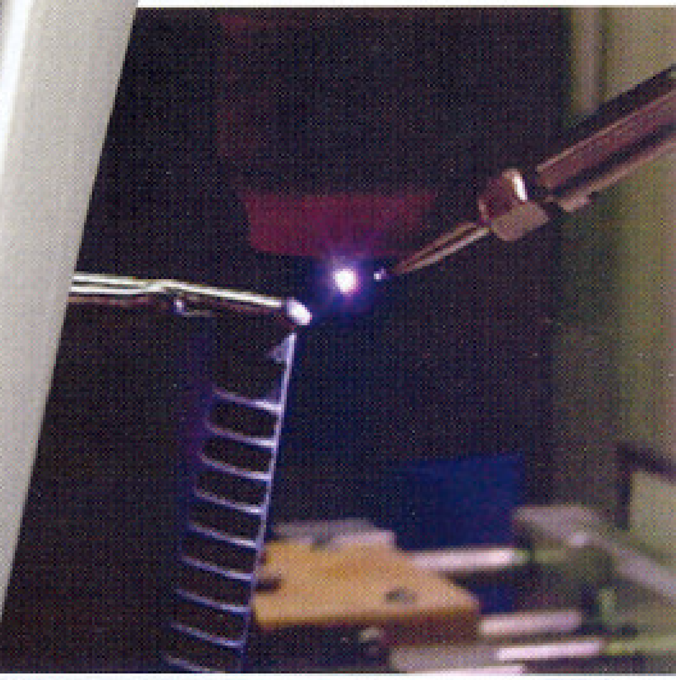


Featured Article:

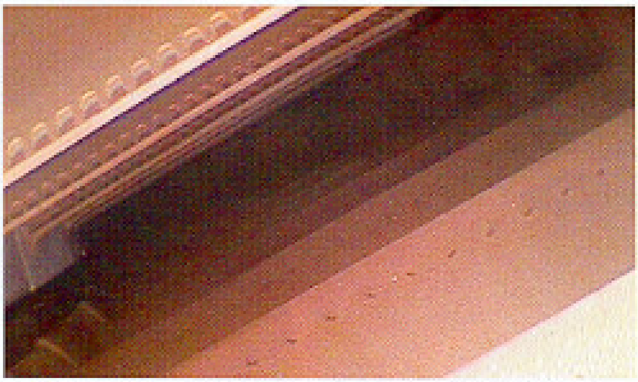
Repair technologies applied from aeros produce high yields on F-class blades, vanes

LIBURDI

Repair technologies borrowed from aeros produce high yields on F-class blades, vanes

Plant managers need suppliers as partners—real partners, ones that have your interests aligned with theirs. There's already too much to do at staff-constrained gas-turbine-based powerplants without also having to worry about whether the equipment and services you purchase will meet contractual requirements for quality and schedule. This is especially true during outages.

The value of real partners was illustrated during the recent refurbishment of stage 2 and 3 blades and vanes for a V84.3A1 peaking unit at Kansas City Power & Light Co's (KCPL) Hawthorn station, located a few miles from the Kansas City airport. The gas turbine (GT) was taken out of service in spring 2004 for a hot-gas-path overhaul after compiling 25,000 equivalent operating hours (EOH) on turbine blades and vanes.


1. **Borescope inspection** after 3300 hours of service and 100 starts following completion of repairs showed refurbished parts were in excellent condition

Hawthorn Combustion Turbine Superintendent Don Scardino's staff committed to an aggressive outage schedule to get the machine back in service for the summer. This Hawthorn asset is a critical machine for the utility: It operates daily.

Pre-outage preparations included the purchase of complete sets of first-stage blades and vanes from Siemens Westinghouse Power Corp, Orlando. Spalling of the original coating specified for these parts made complete replacement the practical choice given outage schedule constraints.

The utility opted not to order complete rows of new blades and vanes for stages 2 and 3, embracing a remove/repair/reinstall strategy to reduce outage cost. However, Scardino did buy 50% new spares for stage 2 and a few spares for stage 3 in case all the blades and vanes could not be repaired. Thus critical to outage success was the selection of service partners capable of conducting the outage and completing, within only 10 weeks, high-quality blade and vane repairs.

Vendor selection

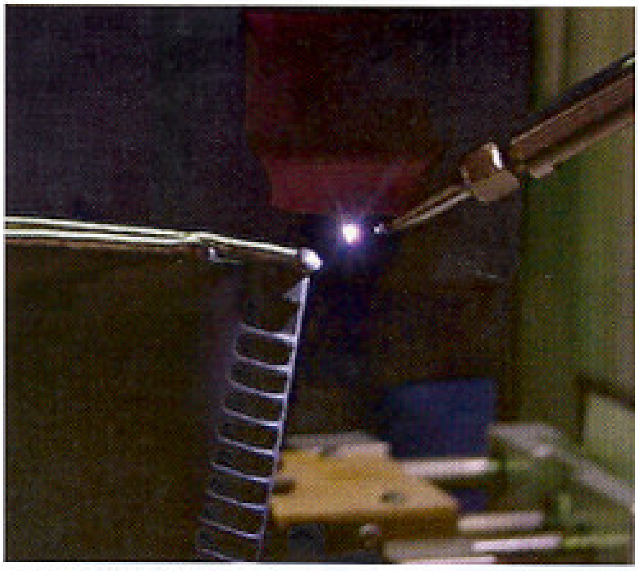
SWPC was hired to manage and conduct the outage, which included opening and closing of the unit, destacking and restacking of the rotor, installation of new/repaired blades and vanes, etc. KCPL selected ReGENco LLC, West Allis, Wis, to manage the hot-section repairs. Note that the company's key personnel came from Siemens Power Corp (the US business unit the preceded the German company's acquisition of Westinghouse Electric Corp) where they were responsible for the installation and service of V64, V84, and V94 engines—including installation of the Hawthorn peaker.

Karl Mattes, ReGENco's combustion turbine business segment manager (kmattes@regencoservices.com, 414-475-2854) suggested to KCPL that the service company's alliance partner, Liburdi Turbine Services Inc, Dundas, Ont, Canada, be considered as the vendor for stage 2 and 3 blade and vane repairs. Scardino added the Liburdi name to the list of prospects, which included a frame GT OEM (original equipment manufacturer) and an aeroderivative GT OEM. A thorough evaluation of capabilities was conducted for all prospective repair shops, including site inspections.

Liburdi was awarded the repair contract based on price and capabilities, according to Scardino. One noteworthy aspect of Liburdi's proposal, he said, was the company's plan to destructively test a representative blade and vane from each stage and conduct a full metallurgical analysis to ensure a high-quality repair. Because contract terms were such that the ReGENco/Liburdi alliance assumed ownership of the blades and vanes when they were removed from the machine, the test components were Liburdi's not the utility's. Other vendors vying for the bid, Scardino said, just wanted to remove the existing coating, make repairs, and recoat based on previous experience and the OEM's original spec.

Results. The repair project described in detail below met the utility's expectations on schedule, cost, and quality, added Scardino. The quality aspects of the repairs were confirmed by a thorough borescope inspection in January 2005, after a demanding 3300 hours of service and 100 starts since project completion in early May 2004.

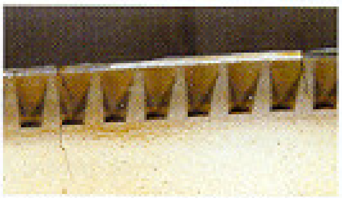
The inspection revealed that refurbished components were in excellent condition (Fig 1). In particular, the upgraded coating system prescribed by Liburdi did not crack like the original coating, and high-tech trailing-edge repairs to second-stage vanes using a proprietary Liburdi process were defect-free.



2. **Automated micro-plasma welding** process works well on single-crystal stage 2 blade material

Planning repairs

F-class engines, such as the V84.3A, rely on superalloys, internal cooling systems, and coatings developed for aero engines to operate at the high temperatures required for achieving top efficiency. Single-crystal and directionally solidified superalloys, although relatively new to frame machines, have been used for many years in aero and land-based aeroderivative engines. Similarly, the serpentine internal cooling systems, internal coatings, and thermal barrier coatings used in F-class GTs have evolved from successful aero engine components.



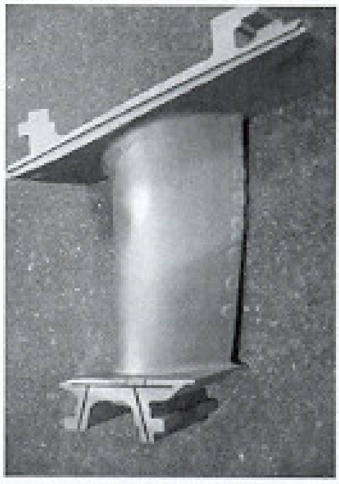
3, 4, 5. **LPM powder metallurgy process** repairs trailing-edge cracks (above); airfoil after blending to restore the original profile is at right

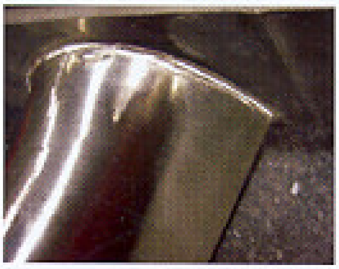
Challenges presented in the refurbishment of high-temperature components for F-class GTs have been met by applying repair technologies developed for aero and aeroderivative engines. Liburdi's experience in refurbishing parts for these machines, as well as for Frame 7FA components, proved it was capable of producing a high repair yield for the V84.3A.

Liburdi's project director for Hawthorn, Lloyd Cooke, PE (lcooke@liburdi.com, 905-689-0734), said the first step in the repair project was cleaning of the blades and vanes, followed by visual inspection and nondestructive examination (NDE). The findings: Stage 2 blades had suffered metal loss and tip cracking; stage 2 vanes, significant cracking at the trailing edge. NDE also identified moderate cracking of stage 3 vanes at both the trailing and leading edges.

Metallurgical analysis. To ensure that all service damage was fully identified and would be addressed by the repair design, Cooke explained, a sample component was selected from each stage and processed through a metallurgical analysis immediately after removal from the engine. Such detailed analysis reveals internal factors that cannot be identified visually and with NDE.

Metallurgists found that second-stage blade-tip metal loss was caused by high-temperature oxidation, while cracking of the blade tips and vanes was attributed to thermal mechanical fatigue—in simple terms, thermal shocks experienced during startups and shutdowns. Also, that the standard coating used for the second-stage blades and vanes had experienced significant cracking. In many cases, that initiated cracking in the base metal, which had to be repaired.





Developing repair procedures

For rebuilding stage 2 blade tips, Liburdi selected an advanced weld alloy with high oxidation resistance—a material that offers greater resistance to oxidation than that used for the original blade casting. This upgrade, said Cooke, would reduce or eliminate future oxidation in service, based on previous experience in high-temperature aeroderivative engines. The single-crystal stage 2 blade material responded successfully to the automated micro-plasma welding process (Fig 2) that had been used by Liburdi many times previously in similar situations.

Conventional welding techniques, by contrast, would have had problems dealing with cracks in the high-strength, single-crystal alloy. Reason: Welding can generate new cracks in the heat-affected zone (HAZ) because of the intense heat and melting/resolidification of the base alloy.

Liburdi's patented LPM power metallurgy process, which relies on superalloy powders for strength, allows repairs without any of the HAZ problems associated with welding. The process used frequently by the company and is authorized by both aeroderivative and frame OEMs for both repairs and new-parts manufacture.

The stage 2 vanes, made from high-strength nickel alloy castings, exhibited extensive cracking in the trailing edges. These cracks also were repaired using the LPM process (Figs 3-5). Incoming trailing-edge cracks are at the left in the group of photos, top right shows cracks repaired with LPM materials after vacuum heat treatments, and the airfoil after the LPM repairs were blended to restore the original profile is at lower right. In sum, the LPM process was selected over welding to permit use of the latest proven high-strength repair materials and to ensure a high repair yield by avoiding potential welding problems.

Examination of stage 3 blades revealed no cracking damage and metallurgical analysis showed that alloy strength was not depleted. The original coating was in relatively good condition, with most of its life (read aluminum content) remaining. Rather than process the parts through unnecessary and costly stripping and recoating, the surface was cleaned and an aluminum-rich diffusion coating applied to rejuvenate the original MCrAlY coating (to dig deeper, consult "Taking the mystery out of GT hot-section coatings," COMBINED CYCLE Journal's 2005 OUTAGE HANDBOOK, Summer 2004, available at www.psimedia.info/ccjarchives.htm). This reduced KCPL's cost while fully restoring the coating life for the next service interval.

Stage 3 vanes were stripped and the cracks in the leading and trailing edges repaired using the same LPM process selected for the stage 2 vanes.

Coating upgrade

The incoming inspections and metallurgical analysis revealed that the original coatings were relatively brittle and prone to pattern cracking. In many cases, the coating cracks had evolved into base-metal cracks that required repair by LPM. To avoid a recurrence of such damage, a different MCrAlY coating composition was selected—one offering similar oxidation protection, but more ductility and crack-resistance.

For stage 2 blades and vanes, both the external and internal coatings were stripped and new coatings applied to complete a full-life repair workscope. This is significant: Internal coatings usually are not replaced because of technical difficulties in stripping the internal passages.

On-time delivery, high yield. The reconditioned second- and third-stage blades and vanes were completed and returned to Hawthorn within the planned 10-week repair schedule. The required high yield also was achieved: 100% for stage 2 vanes and stage 3 blades and vanes. One stage 2 blade had to be scrapped because the difficult location of a defect prevented a reliable repair; yield for that row was 98%.

One final note: Even though the repaired components were delivered on time, Scardino had SWPC install the half row of new stage 2 blades and vanes that KCPL had purchased. These components were available onsite before the repaired blades and vanes were delivered and KCPL was able to reduce total outage time by about a week in using them. CCJ