Shops verify as-received condition of components with an 'incoming' inspection

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This is the third in a series of four articles outlining the six critical steps to successful refurbishment of industrial gas-turbine (GT) parts.

First two steps (published in the COMBINED CYCLE Journal, 2Q/2005) described onsite assessment of component condition and development of repair specifications. Step 3, guidelines for selecting the appropriate repair vendor(s) to meet your plant's specific needs, was presented in the 2006 Outage Handbook supplement to the 3Q/2005 issue.

This article describes Step 4, the vendor verification process for incoming inspection. Steps 5 and 6, covering vendor verification of repair, coating and inspections performed during the refurbishment process, and final inspection of refurbished components will be published next issue.

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Stage 1 of repair process: Initial inspection

After assessing the condition of GT components at the plant site, creating repair and coating specifications, and selecting the repair vendor, your parts can be released for refurbishment and recoating. The first of four stages in the repair process is confirmation of component condition (refer to flow chart included in the 2Q/2005 article, available online at www.psimedia.info/ccjarchives.htm).

This involves taking dimensions in the as-received and assembled condition at the repair facility, as well as conducting a visual inspection and a metallurgical evaluation. An engineering report reviewing all findings should confirm that the scope of work will produce the desired end product. If discrepancies surface, the end user or its representative should review the components, inspection reports, and recommendations, and then meet with the repair vendor. Work should be stopped until after that meeting. A revised scope of work may be necessary.

Stage 2 of repair process: Disassembly and incoming inspection

After the scope of work is confirmed, or modified to reflect the findings of the initial inspection, the component is disassembled from its retaining ring, blocks, etc. It is important that the work order clearly define which components and parts will be refurbished and reused and which will be replaced. Next step is to remove hardware such as seals, pins, core plugs, covers, zippers, and bolts.

Stripping/cleaning of parts slated for refurbishment are important steps: Clean surfaces are required to ensure successful inspection, repair, and recoating. Confirmation of surface cleanliness is highly recommended prior to pre-weld solution heat treatment. Heat tinting and macro etching are two techniques used to assure that the degree of cleanliness required has been achieved.

After pre-weld solution heat treatment, nondestructive examination (NDE) should be performed to identify any cracking, wall thinning, and cooling-hole blockage (Fig 4-1). Dimensional checks define deflection of walls, airfoils, shrouds, z-notches, etc.

4-1. Dye-penetrant testing reveals coating cracks

What follows is a series of thumbnail sketches describing the key actions required during Stage 2 of the repair process to assure accurate verification by the repair vendor of component condition:

Initial visual inspection. Purpose of visual inspection at this stage essentially is to confirm the degradation modes identified during the onsite inspection. Occasionally, however, the better lighting and higher-magnification inspection tools—and more experienced personnel—available in a shop environment reveal damage not observed at the plant. Be sure to document these items with digital photography and investigate further such important findings as coating cracks and rimming, oxidation, corrosion and erosion, and wear. In some cases, extensive metallurgical evaluation—even destructive testing—is necessary to obtain the information needed to ensure quality, long-lived repairs.

If the end user's onsite findings differ significantly from degradation identified in the shop, the plant should consider redefining its inspection procedures to bring them in-line with current industry practice.

Metallurgical evaluation. Representative metallurgical samples, as well as samples from locations of special concern identified in the preceding visual inspection, are removed for closer examination. Using a microscope, a qualified metallurgist can accurately assess the condition of the base material and internal and external surfaces.

Further definition of the base material, coatings, environmental attack, and other deterioration can be obtained using a scanning electron microscope equipped with energy dispersive x-ray microanalysis capability. It is good practice to examine samples, both etched and unetched, at low (50X), medium (500X), and, in the case of gamma prime, at high (10,000X) magnification.

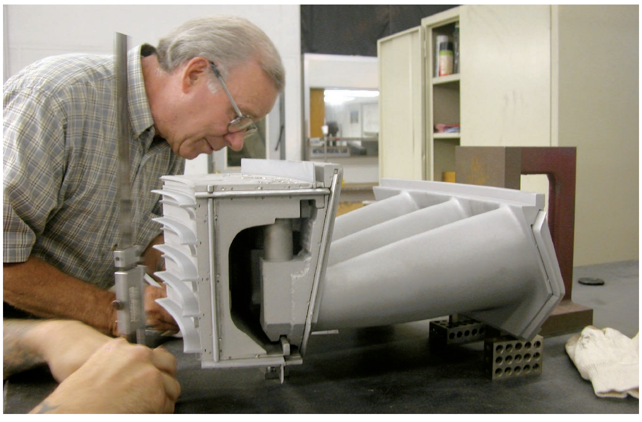
Metallurgical findings should be used to confirm or fine-tune the refurbishment process—for example, to suggest the proper stripping method, to help identify the optimum coating system for your application, etc. The metallurgist's report also provides valuable feedback to the end user regarding the level of success of previous repairs and coatings, the identification of manufacturing flaws, and the expected lifetimes of components based on their current condition and anticipated future operating regimes.

Dimensional inspection. The initial, as-received inspection helps identify issues associated with the fit-up of various components—such as those associated with clearances, throat opening, seal grooves, bucket rock, and z-notch contact area. This portion of the vendor verification process relies on the use of inspection fixtures (Fig 4-2) to replicate the location and position of a given component within the GT—thereby enabling accurate inspection and measurement of critical dimensions (for example, wall thickness, deflection, tip height). The information gathered helps to identify any special needs that should be addressed during refurbishment. Or, in the extreme, it may suggest that component replacement should be considered.

Stripping/cleaning and surface inspection. The stripping plan developed for a given component should consider its base material and coating as well as its condition as determined by metallurgical evaluation. Most of the coating is removed by chemical stripping or water or grit blasting. Coating material and/or corrosion/oxidation products remaining after this step are removed by hand blending following a heat tint of macro-etch, a procedure that is repeated until the surface is completely clean (Fig 4-3).

Removal of coatings from components with very thin walls demands special care to ensure that the integrity of the base material is not compromised. Process usually is time-intensive. Be wary of repair facilities that suggest otherwise. Note that it is not always necessary to remove all of the bondcoat on these components. However, success weighs heavily on having a proactive owner/operator available to verify that the coating is removed to the extent required without damaging the base material.

Heat treatments typically are performed in a vacuum furnace; argon and hydrogen furnace atmospheres sometimes are viable alternatives to a vacuum. Heat-up and cool-down rates, as well



4-2. Downstream deflection is measured to determine the amount of correction required

4-3. Heat tinting of liners should confirm that all coating has been stripped

as time at temperature, are critical parameters for achieving the desired metallurgical and mechanical properties. To ensure quality heat treatment, verify furnace atmosphere, temperature, pressure, etc, with proper monitoring/recording instrumentation. Also, request feedback from follow-on heat-treatment cycles to ensure that the desired metallurgical and mechanical properties were indeed achieved.

Nondestructive examination. NDE alternatives for assessing component condition after pre-weld solution heat treatment include visual, liquid penetrant, ultrasonic, eddy current, and x-ray testing. Depending on component condition, one or more methods is suitable for identifying cracks on or below the material surface, pinpointing cooling-system problems, and measuring wall thickness. Special methods, such as flow and frequency tests, can be helpful in identifying problems such as overheating and high-cycle fatigue.

The owner/operator should compare the repair vendor's NDE results to its expectations based on visual and dimensional (clearances) inspection at the plant and component operating history. If discrepancies surface, the end user or its representative should review the components, inspection reports, and recommendations, and then meet with the repair vendor. Work should be stopped until after that meeting.

Engineering review of Stage 2 inspection results is necessary to ensure that the existing scope of work for the refurbishment effort is conducive to achieving the desired results. As described above in Stage 1, repair work should not proceed until the end user, or its representative, reviews the inspection reports and recommendations and discusses them with the repair vendor.

Don't be reluctant to make necessary changes to the scope of work at this point in the refurbishment process. However, be sure to factor any commercial and delivery-time penalties into your analysis. Finally, if any changes are made to the scope of work, specifications, and schedule, be sure to update the verification points in the repair process as well as final acceptance terms—if applicable. You'll sleep better knowing you have done everything possible to ensure reliable operation of your GT through the next cycle. CCJ