QUALITY SCAN

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Waterjet as a Stripping Technology

Superalloy components used in gas turbines require coating systems to protect the base metals. These coatings resist the oxidation and corrosion created by the combustion process in the turbine, and also resist removal when they become depleted.

Most modern hot-gas-path coatings consist of a ceramic thermal barrier coating (TBC) on the outer surface, and a MCrAlY bond coat between this material and the base metal. Acid stripping and grit blasting to remove these coatings can cause metallurgical damage and dimensional changes.

Typical problems caused by acid stripping include intergranular attack (IGA). Many OEMs and users limit part repairs to one cycle because of IGA. Acid requires masking to avoid removing the internal coatings, and subsequent unmasking. A poor mask can destroy internals and cause the part to be scrapped. Acid also attacks braze from previous repairs, reducing part life and the number of repair cycles. Stripping with acid doesn't remove the bond coat evenly or uniformly, so parts must undergo hand processing. Internal cavities and areas like the blade root in a turbine must be protected from strong acids. Further, control of the acid bath requires careful monitoring. Bath chemistry changes constantly due to part/acid reactions, and evaporation losses.

Removing coatings with a CNC waterjet is a tightly controlled mechanical process.

Because of shortcomings in the acid-stripping process, a grit-blasting process follows acid stripping.

Grit blasting is a hand-held operation done by a plant's least-trained personnel. The least-controlled of all repair processes, it's also the most widely used. It's difficult to insert a blast gun into a liner and hold any consistent tolerance. Because the coating and base metal are both grey metallic in color, it's hard to distinguish the coating from the metal. So it's not surprising that grit blasting often results in uneven material removal and base metal thinning (which distorts geometry). In addition, blasting contaminates the surface interface with Al_2O_3.

Because of incomplete bond coat removal and contaminated surfaces, patches—even sheets—of coatings are known to come off in initial service, or before normal warranties run out. Sometimes coatings come off as they are applied, causing rework as high as 40%.

In contrast, precision abrasive waterjet processing can remove coatings without damaging the component. A five-axis CNC abrasive waterjet will remove a coating in iterative steps. Material removal rates are controlled by speeds, feeds, pressures, and abrasive material flow. A X-ray fluorescent device is used to measure the Yttrium K-alpha peak to determine the amount of MCrAlY and bond coating remaining. As the base metal is approached the peak diminishes, and iterative passes allow the unit to "sneak-up" on the base metal. With this type of control, and the reduction in substrate damage it yields, additional repair cycles sometimes can be realized.

Removing coatings with a CNC waterjet is a tightly controlled mechanical process, and is able to hold positional tolerance to less than 0.0005" (0.0127 mm). The waterjet stream is controlled to a specified distance from the surface, with feed and speed controlled to keep the offset normal over the entire form of—for example—a turbine blade. Coating thickness is measured before and after the removal step, to ensure full removal of the bond coating and diffusion layer, as well as any contamination corrosion beneath the bond coat. The process removes craze cracking and deep cracks better than fluoride-ion cleaning.

The remaining surface is cleansed of all surface contamination, and in some cases shows directionally solidified grain structure and etching. Process controls measure before-and-after conditions to verify coating removal over the surfaces where it's required. Most companies that use this method then bag the part and send it directly to coating. Grit blasting, on the other hand, recontaminates the surface and destroys the bond interface.

Because of CNC, single-part flow occurs that reduces the risk of the batch-lot errors that can occur during acid stripping. The process can remove the TBC and bond coat in one process, and part-processing time is less than that required for acid stripping and grit blast.

In addition, abrasive waterjet stripping can eliminate the human variable found in hand grit blasting and permits the generation of run charts; process parameters are controlled by the CNC. All these characteristics improve the quality of cleaned gas-turbine parts, and eliminate the environmental issues associated with the disposal of chromium and other heavy elements leached from superalloys by acid stripping, as well as the residue caused by grit blasting.