HARD-COATING REMOVAL that's easy on the environment

Abrasive water jet removes ceramic coatings without damaging substrates or creating toxic waste.

Abrasive water-jet (AWJ) coating-removal processes are emerging as a greener alternative to acid baths and grit blasting. Proponents of AWJ say it can cut down on rework and extend part life. If you're faced with a tough coating or surface-preparation problem, here's what you need to know.

The jet set

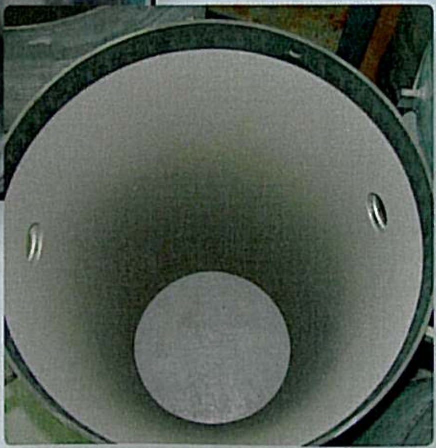
The AWJ process works especially well on tough coatings that see extreme environments, like molybdenum-chromium-aluminum-yttrium (MCrAlY) ceramic thermal-barrier coatings (TBCs) that protect superalloys in gas turbines.

Despite careful engineering of the coatings, intermediate bond layers, and underlying alloys, surface protection becomes depleted during operation, and coatings must be removed and replaced. Maintenance personnel often rely on acid stripping and grit blasting to remove the tough coatings. Both processes can damage the underlying metal and change part dimensions.

AWJ processes, on the other hand, remove the coating iteratively using five-axis CNC programming. The controller governs speed, feed, and pressure and keeps the water-jet nozzle a set distance from and perpendicular to the surface, even over highly contoured surfaces. The system holds tolerances of less than 0.0005 in.

Water pressures are in the 10,000 to 50,000-psi range. The water carries ceramic abrasives; garnet is one common choice. Abrasive particle size can vary depending on the application and is usually proprietary to that process.

Water, abrasive, and material removed from the part are collected in a holding tank. After settling, the residue is sent to a landfill. The process



Harsh, oxidative environments damage even tough coatings, which must be completely removed before new coatings can be applied. Abrasive water jet, coupled with X-ray fluorescence inspection ensures coating removal down to the base metal.

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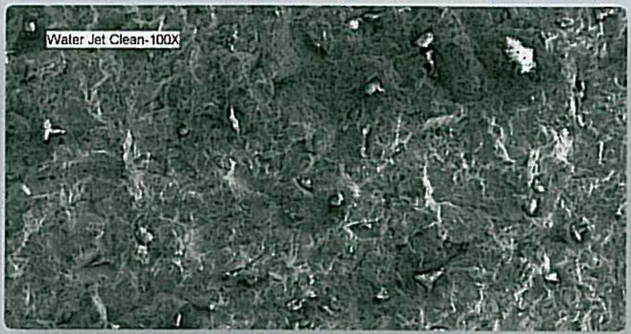
Key points:
- Abrasive water-jet systems use CNC programming for repeatable removal of tough coatings.
- AWJ is a mechanical process that does not generate toxic by-products.
- Removing coatings with AWJ can mean less rework, longer part life, and a greener process.

Resources:

Huffman Corp., *huffmancorp.com*

Springfield Manufacturing LLC, *springfieldmfgllc.com*

"Cool coatings let engines run hotter," Machine Design, Dec. 12, 2002, *machinedesign.com/article/cool-coatings-let-engines-run-hotter-1212*



Grit blasting can leave behind fragments of its aluminum-oxide abrasive. Abrasive water-jet processing entrains abrasive materials like garnet in a high-pressure stream of water that also removes debris.

is mechanical, unlike acid baths, so it doesn't generate toxic metallic ions such as hexavalent chromium.

Because coating thicknesses naturally vary, the process should include pre and postwater-jet inspection. X-ray fluorescence devices measure the K-alpha peak of yttrium or other rare elements. The peak is proportional to element concentration and diminishes as the coating thins. Operators monitoring the K-alpha peak between treatment iterations ensure the process fully removes the desired material without damaging the base metal.

By preserving the base metal, processors can extend part life with added permissible repair cycles. AWJ also removes craze cracking and deep cracks better than fluoride-ion cleaning.

High-pressure water prevents entrapment of the abrasive in the material, so AWJ-treated parts are generally clean enough to be inspected, bagged, and sent to a coating operation without additional surface preparation.

The automated system cuts process variability by reducing operator error. It can also generate run charts to help optimize the repair line consistent with a Six Sigma philosophy.

AWJ coating removal costs 75 to 110% as much as acid baths or grit blasting. Less scrap, additional repair cycles, and longer part life further improve its bottom line.

Acid anxiety

Acid baths have traditionally been the method of choice for removing tough ceramic coatings, but they do have several drawbacks.

The batch-processing nature of acid-based coating removal creates workflow bottlenecks. Any problem with a particular acid bath can mean scrapping or reworking an entire batch of parts.

Because acid reacts with the coating, bath chemistry changes during part exposure and from bath to bath. Workers must carefully monitor and adjust bath composition to keep the process consistent.

The acid reaction also means some coating components go into solution. Dissolved chromium from MCrAlY coatings makes the process fluid a toxic waste subject to EPA-imposed permissible exposure limits.

Acid exposure can result in stress-corrosion cracking, pitting, and alloy depletion. Acids weaken vulnerable spots in the metal, like the boundaries of microscopic metallic grains, leaving them open to further corrosion. The risk of this kind of intergranular attack has limited parts to a single acid-bath repair cycle.

Acid also attacks brazed joints, soaking into the porous filler metal, prolonging exposure, and complicating acid removal.

Complex gas-turbine parts must be masked before an acid bath to keep internal coatings intact and protect highly stressed part sections, like blade roots, from the strong acids. Although masking and demasking are not value-added processes, they are necessary; a poorly applied mask can destroy internal details and force workers to scrap the part.

Even if sensitive areas are adequately protected, a turbine part coming out of acid stripping may need to be processed further because the acid bath does not always remove the bond coat uniformly. Parts often need grit blasting prior to recoating to remove the rest of the original coating and clean off contaminants called smuts the acid leaves on the alloy surface.

Grit gripes

But grit blasting also has its drawbacks. When coarse aluminum oxide grit strikes the hard blasting surface, it breaks into fine particulates which, along with fragments of the coating being removed, contaminate the part surface and compromise the substrate-coating bond.

Contamination can lead to patches of a new coating peeling off during application or when the parts are first put back into service. Some shops report rework rates as high as 40% from bonding-surface contamination.

The convoluted design of many parts means it can be hard for operators to maintain a consistent spray distance and duration for even material removal. Because the coating and base metal are often the same color, operators can have trouble distinguishing which material to remove and wind up inadvertently thinning the base metal.

The human factor in grit blasting and the batch nature of acid dipping usually mean that these processes take longer than AWJ. In some cases, grit-blasting on its own can be slightly less expensive, but proponents say users should factor in additional repair cycles and the longer service life of AWJ-processed parts, too. **MD**