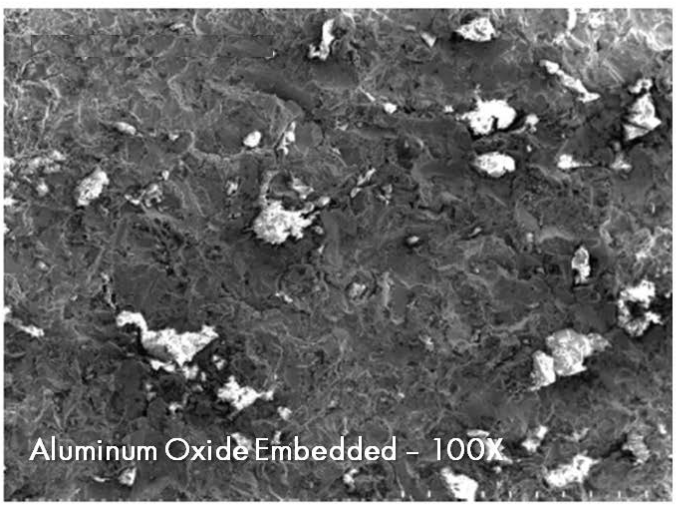
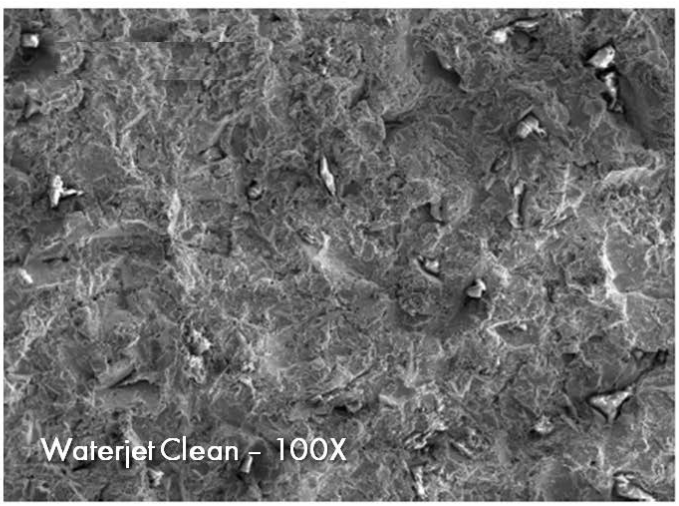
The Clean, Green Coating Removal Solution





The precision abrasive waterjet (AWJ) process is a higher quality and more cost effective means of coating removal than traditional acid stripping and grit blasting. Huffman, LLC provides an overview of the key points of interest.

Superalloy components require coating systems to protect the base metals from the extraordinary operating environments of gas turbines. These tenacious coatings are designed to resist the oxidation and corrosion created by the combustion process in the turbine hot gas path. These coatings also resist removal when they become depleted during operation.

Most modern hot gas path coatings consist of a ceramic thermal barrier coating (TBC) on the outer surface and a "bond" coat between this TBC and the base metal. Typically, acid stripping and grit blasting of these bond coatings from superalloy components can cause both metallurgical damage and dimensional changes.

Acid stripping and grit blasting of MCrAlY bond coatings from vanes, blades, shrouds, liners and transition pieces are destructive processes. Exposure to acid can result in stress corrosion cracking, pitting, and alloy depletion. Grit blasting can result in uneven material removal and thinning of the base metal. Also there are environmental considerations to bear in mind and these are becoming increasingly important.

An AWJ process gently removes the coating without compromising the base metal integrity. There are no inter-granular attack or other issues involved. The process is the cleanest, most efficient and most repeatable process for removing MCrAlY coatings from hot gas path components. AWJ is also environmentally friendly and it is gaining momentum as the preferred method for the factory of the future.

Compare stripping processes to see the difference.

Acid Stripping

Typical problems from acid stripping include inter-granular attack (IGA). Many OEMs and users limit part repairs to one cycle because of IGA. In addition to the IGA, acid stripping leaves smut that contaminates the interface.

Acid requires masking to avoid removing the internal coatings, and subsequent unmasking. That is expensive and adds no value. A poor mask can destroy internal structure and cause the part to be scrapped. Acid stripping is a batch lot process and it is not unusual to find a group of parts being damaged due to acid variability.

Acid attacks braze from previous repairs thereby reducing part life and the number of repair cycles that can be accomplished, adding to the total costs of operation. Braze

metal in brazed joints are often attacked due to the difference in material composition and porosity. Braze tends to absorb the acid and make it difficult to remove whereupon acid attack occurs.

In addition, acid stripping does not evenly or uniformly remove the bond coat. Parts require subsequent hand processing to clean, adding more labour cost.

Internal cavities and areas such as the highly stressed blade root must be protected from strong acids. Also, control of the acid bath requires close monitoring. The process is 'dynamic' and the chemistry of the bath is constantly changing due to the part/acid reactions and losses due to evaporation.

The intent of the acid bath is to strip coatings but the by-products are both costly and damaging. There are also environmental issues and costs to factor in.

Both aero and industrial applications are particularly vulnerable since their super-alloys contain materials such as chromium and similar heavy elements. When these materials are put into solution they become toxic in nature. Personal exposure limits have recently been lowered by the EPA to lessen the probability of long-term health issues due to exposure to such materials.

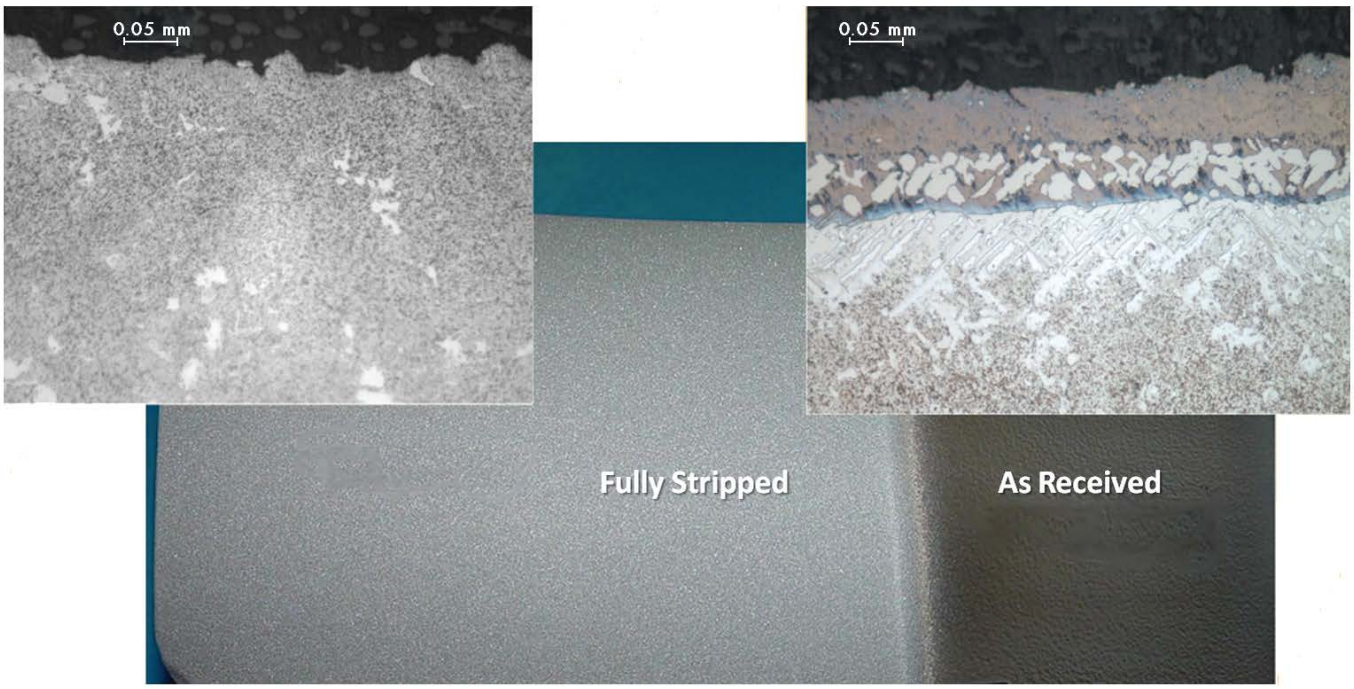
Because of shortcomings in the acid stripping process, like incomplete removal and smut, a grit blast process follows.

Grit Blasting

Grit blasting with aluminium oxide also has its drawbacks. It is a hand-held operation and is done by the plant's least trained personnel, and is the least controlled of all repair processes, yet the most pervasively used.

Grit blasting can result in uneven material removal and thinning of the base metal. The coating and the base metal are both grey metallic in colouring, which makes it hard to distinguish the coating to be removed from the base metal. With a hand-held grit blast operation, uneven removal is the normal result. Grit blast guns use coarse grit that breaks down to finer grit during a typical liner blasting leaving a dirty residue. Hand manipulation of the gun is difficult in certain circumstances, such as on the inside of a combustion liner. In such circumstances it is difficult to consistently control tolerances, especially when the colours of the coating and the base metal are so similar.

AWJ precision process cleans better, protects better and extends usefull part life, lowering total cost.



Coating removal - IGT Bucket: the photo above shows the as received condition on the right and the transition to a fully stripped coating on the left. The part was not masked and allowed for a smooth gradient from the coated to the stripped section.

The results of grit blasting are uneven coating removal, and distortion of part geometry and the contaminating of the surface interface with aluminium oxide (ALOX). Most turbine manufacturers control the amount of contamination in the interface between the coating and the substrate. Alumina contamination negatively impacts the tensile bond integrity. Because of incomplete bond coat removal, and contaminated surfaces, patches and even sheets of coatings are known to come off upon introduction into service, or long before normal warranty outages. Sometimes coatings come off as they are applied, causing as much as 40 per cent of parts to be reworked. Worse still, many repair processes call for additional grit blasting if residual grit is found at fluorescent particle inspection! More grit (dirt) perpetuates the problem.

Abrasive Waterjet (AWJ)

AWJ is an environmentally friendly process that removes coatings without damaging the turbine component while lowering total costs.

A precision 5 axis computer numerically controlled (CNC) abrasive waterjet (AWJ) removes the coating in iterative steps. The process behaves like a machine tool with material removal rates being controlled by speeds, feeds, pressures and material flow.

Since coating thicknesses naturally vary, an X-ray fluorescent device reports elements like Yttrium that decline in intensity as the base metal is approached. With this type of process control, it is sometimes possible to realise additional repair cycles in some components due to minimal damage to the substrate.

This CNC process has many advantages. Firstly, it is a highly controlled mechanical removal process — akin to a surface milling process with tight tolerance control. It does not put chrome into solution, like acid. It is a mechanical removal process. The machine is actually capable of holding positional tolerance to less than 0.0005 inch. The waterjet stream is controlled to a specific distance from the surface, with feed and speed controlled by software that keep the offset normal over the entire form of a blade for example. Coating thickness is measured before and after the AWJ to insure full removal of the bond coating and diffusion layer, as well as any contamination, such as corrosion, under the bond coat. The process has the consequence of removing craze

cracking, and deep cracks better than fluoride ion cleaning.

The remaining surface is also cleaned of all surface contamination and in some cases shows directionally solidified (DS) grain structure and DS etching. Most companies using this method then bag the part and send directly to coating. Grit blasting re-contaminates the surface and destroys the bond interface. Process controls are in place to measure conditions before and after to verify removal over the surfaces where it is desired.

Because of the CNC processing, single part flow occurs that beneficially reduces risk of batch lot errors. Actual part processing time is much less than acid and grit blast, usually at lower total costs. The AWJ process can remove the TBC and bond coat in one process. Grit blasting of TBC and bond coating in some cases may be slightly lower in terms of cost but at the higher total expense of lower service life and a reduced number of repair cycles.

- The system utilises Six Sigma philosophy eliminating the human variable found in hand grit blasting.
- Run charts can be generated.
- All process parameters are controlled by the CNC control system.
- An X-ray fluorescent device is used to measure the Yttrium 'K-alpha' peak to determine the amount of MCrAlY bond coat remaining. As one approaches the base metal, the peak diminishes, thereby allows 'sneaking up' on the base metal with iterative passes by the unit.
- The high-pressure water prevents entrapment of the abrasive in the material, so the part is much cleaner than a grit blasted part.
- Parts can often be coated after waterjet without an aggressive grit blast process. This will speed the part through the repair process.
- The AWJ process can remove the TBC and bond coat in one process.

Extensive scrutiny, qualification and approval by users, independent service providers and major OEMs over the last five years has resulted in increasing use of the AWJ stripping process in almost every application ranging from blades, vanes, liners, transition pieces and shrouds. The results are predictable, repeatable, and environmentally friendly.

The process was developed and patented by Huffman, LLC in conjunction with Springfield Manufacturing (US patent 6,905,396). The process utilises Huffman's multi axis machine tool technology, together with its super-abrasive grinding machine platform used for tight tolerance gas turbine component machining. The AWJ machining service is available from Springfield Manufacturing which has seven machines available to service your requirements. Aerospace and industrial gas turbine original equipment manufacturers work with Springfield to seek out applications where cost, cycle time, and improved repairability can be realised with green manufacturing.