Nickel Based Alloy IGA

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Abstract

Nickel based alloys are utilized in gas turbine engines as they exhibit a combination of high temperature strength, toughness and resistance to degradation in corrosive or oxidizing environments. In some turbine disc manufacturing processes, in order to prepare the component surface for Fluorescent Penetrant Inspection (FPI), a pre-penetrant etch is used. The process solution, temperature and time must all be considered when selecting a pre-penetrant etch process. If not tested for alloy compatibility the potential for IGA can go undetected and eventually lead to component failures in the field.

Keywords: Pre-penetrant etch, intergranular attack (IGA), aerospace, nickel

1. Introduction

Pre-penetrant etch is a routine operation in the manufacturing of many components. The operation consists in chemically of removing a few microns from surface of a component or an area of a component using an acid or alkali process solution for a certain amount of time at a set temperature. This is usually as preparation for penetrant inspection and the intent is to remove smeared material and open to the surface discontinuities that might not have been otherwise. A successful pre penetrant will removed the specified amount of material without causing harm to the part or be detrimental to its intended use.

2. Process controls

Many parameters should to be monitored and the obvious ones are controls of solution composition, temperature and immersion time.

Selection and composition of the process solution is important, it must be corrosive and remove material evenly. Preferential etch of microstructural feature such as grain boundaries must be avoided. Composition must be controlled at regular intervals and maintained within prescribed values.

Control of temperature must also not be neglected. For many of the etchants, higher temperature will increase reactivity. With this increase certain side effect may manifest themselves and be detrimental to hardware.

Immersion or dwell time is the other base parameter. Increase in immersion or dwell is a direct increase in material removal although it's rarely in a linear function. Prolonged immersion might also be detrimental to parts either by removing more material than necessary or by promoting selective attack.

Other factors and variables can be as important. Specimen preparation and surface finish are also factor to control. Cleanliness is actually the first factor to control when performing any etching operation. Depending on the etchant an unclean surface might not etch evenly and may cause permanent cosmetic or visual defects. Cleanliness can be achieved a variety of

ways such aqueous cleaning/degreasing, vapor degreasing or even grit blasting. In the latter case, this operation must also be done with care and match with the pre penetrant etching procedure to insure that the correct amount of material is removed and that blasting operation did not cause any additional quality issues. Surface finish will have an influence as rougher surfaces will have more surface exposed to the etchant.

Dissolved metal in solution will interfere with the etching process. Depending on the alloy and the solution its tolerance will vary. Normally the threshold should be set so that the solution at with the maximum dissolve metal in it will still yield an acceptable amount of material removal.

Standard testing should include stock loss, titration, and amount of dissolved metal in solution. All of which will alloy to determine process solution "health". This should be done at regular intervals based on usage to insure conformity when processing parts. Adjustments should be made to guarantee that the process solution will stay confirming between tests. Supplemental test is often required; verification on specimens of end grain pitting and intergranular attack is often seen.

Stock loss is often used as the only test method. This can be because of available resources or economic factors but it doesn't give a full representation of the solution condition. Stock loss is a known reference just as the "TAM" panel for FPI. Material removal on the panel will rarely be on for one. Balance of chemical in process solutions cannot be established. But for certain solutions it can be the only testing method available.

On most components, the expectation is to avoid or greatly limit selective attack. Required test is usually done at regular intervals, as it is a test that captures only a moment in time. Intergranular attack is one of them; this phenomenon is corrosion occurring preferentially at grain boundaries, usually with slight or negligible attack on the adjacent grains (Fig. 1).

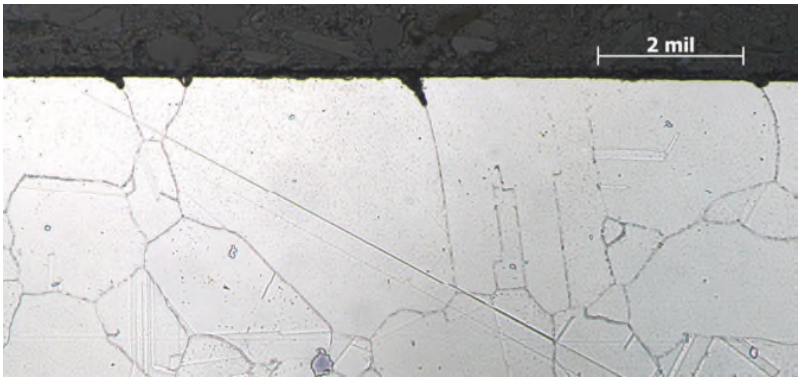

Figure 1

IGA will not be detected at penetrant and may, long term develop into cracks. Then penetrant sensitivity will be crucial as these might be very difficult to detect because of their size and if numerous appear as background (fluorescence). Uncontrolled pre-penetrant etch can result in component failure (fig. 2).

Figure 2

Pre-penetrant etch should be “proceduralized” and contain controls, verifications and operating parameters. Criticality of this operation can be easily underestimated when it becomes a routine operation; procedures must be followed and when results adequate cannot be achieved the root cause must be investigated, even if reprocessing (without proper authorization) the part or component would yield an acceptable result. Consequences in lack of process control are numerous and potentially important.