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PROCESSING OF ALUMINUM 7075-T73 COMPONENTS AFTER PROLONGED STORAGE

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Abstract

Three years ago, production requirements for a T73-tempered aluminum 7075 (Al 7075-T73) component were curtailed and the "in-process" parts were stored. During recent attempts to complete processing, visible defects were discovered in this component. Defects at such an early stage in the 20+ year lifetime of the component pose reliability concerns. Chemical and microstructural analysis, mechanical testing, and corrosion evaluation were performed to determine the impact of the defects on material properties.

Introduction

Three years ago, production requirements for an aluminum 7075-T73 component were curtailed and the vendor went out of business. The components that were "in-process" were placed in plastic bags and stored in wooden crates. Production was halted at various stages of manufacture. Some of the production steps are described below:

- Start with Al 7075-T6 plate
- Anneal to W condition
- Hydroform to rough size and shape
- Age to T73 condition
- Mask and chemically mill
- Conventional milling and drilling
- Mask, degrease, alkaline clean, mild etch, and deoxidize
- Conversion coat
- Mask, degrease, alkaline clean, mild etch, and deoxidize
- Anodize and hot water seal
- Final inspection

Recently, an attempt was made to complete processing of these components because of additional demand for Joint Test Assemblies (JTA's). Since a majority of the total cost for the product had already been incurred, fiscal constraints urged us to complete processing on these partially fabricated products. A new vendor began processing components that had been previously processed through the conventional milling and drilling stages. Inspection of the first 25-30 parts from the new vendor showed defects visible with the naked eye with an associated dark material in the conversion-coated portion of the component that had not undergone chemical milling. This lead to an inspection of stored parts that had not undergone further processing. It was found that these stored parts also exhibited visible defects and associated dark material. Initial cross-section optical microscopy revealed pits on the surface and voids in the bulk of these components. These surface and bulk defects raised concerns about the mechanical integrity and corrosion resistance of these components.

We performed a comprehensive materials characterization on a number of components to determine the effect of the observed defects on materials properties. These components came from two lots. The first lot had undergone the production steps up to and including conventional milling and drilling. The second lot had undergone the complete production to final inspection. Chemical and microstructural analysis and mechanical testing were performed on the first lot and corrosion evaluation was performed on the second lot. Our intent was to assess the impact of this problem on JTA's and to provide guidance concerning the disposition of the "in-process" components.

Chemical and Microstructural Analysis

Our objective in this part of the investigation was to determine if the composition of the components corresponded to that prescribed for an Al 7075-T73 alloy and to determine the chemical composition of the dark material observed in the surface defects on the components. We performed chemical analysis of bulk samples using inductively coupled plasma mass spectroscopy (ICP-MS) and of defect areas using scanning electron microscopy (SEM) energy dispersive spectroscopy (EDS). Results from ICP-MS demonstrated that the chemical composition of two representative samples from the components was within the limits for nominal Al-7075.

Chemical analysis of the components by SEM-EDS showed that defect areas contained enriched amounts of Si, S, C, O, and Mg when compared to other areas of the same sample. We believe that the enriched amounts of Si, S, C, O, and Mg can be accounted for by aluminum and magnesium corrosion products (as indicated by the enrichment in O and Mg) associated with residual machining oil (as indicated by the enrichment in Si, S, and C) in the defect areas.

Microscopic examination of the defects using cross-sectioned samples of the components showed that surface pits did not form at intermetallics precipitated in the alloy by the T73 tempering process. Thus, preferential corrosion at intermetallics from such production steps as the alkaline clean or mild etch cannot account for the surface pits. Also, no crack propagation from the surface defects was evident. Finally, in these samples, no voids were observed in the bulk of the alloy.

Mechanical Testing

We performed mechanical testing of samples from the components to determine if yield strength, tensile strength, and strain-to-failure were compromised by the presence of defects in the samples. Shown in the table below are results from mechanical testing of component samples cut both parallel and perpendicular to the rolling direction of the material. Although the mechanical strength of the components is slightly below that reported by Alcoa and Kaiser, we believe that these differences are due more to test technique than to a negative effect brought on by defects in the components. Our mechanical test specimens were not completely flat due to the curved shape of the components.

Property	Parallel to rolling direction	Perpendicular to rolling direction	Nominal Properties Alcoa	Nominal Properties Kaiser
Yield Strength (MPa)	399±8	410±9	435	434
Ultimate Tensile Strength (MPa)	466±4	489±6	505	503
Elongation (%)	9.9±1	9.3±2	13	13

Corrosion Evaluation

We performed salt spray testing per ASTM B117 (two weeks at 98F in a 5% salt fog) to determine if the surface defects in the components show increased susceptibility to corrosion. This testing was performed on components that had undergone all the production steps outlined above but had been rejected because of visible surface defects in the conversion-coated portion of the component. In tests of 460 in^2 of component surfaces, approximately 70 corrosion pits were observed. MIL-C-5541E specifies that no more than 5 corrosion pits are allowed per 30 in^2 test panel or 15 pits per 5 panels (resulting in an allowable 46-75 corrosion pits over our test area). Although 70 pits is high, the salt spray performance of these samples is acceptable. Of more interest, the pre-existing defects on the surface did not increase in size nor produce tails of corrosion products after salt spray exposure.

Conclusions/Recommendations

The bulk voids observed in the initial optical micrographs were not seen on the samples we received. We believe that the bulk voids, which were the cause for our concerns about the mechanical integrity of the components, could have been caused by sample-to-sample variation or sample preparation. In any case, the mechanical strength of the components does not appear to be compromised by the presence of defects in the bulk or on the surface of the components.

The surface defects observed in the components do not appear to be associated with preferential corrosion at intermetallics. The dark material associated with these defects is likely due to incomplete degreasing of the component after conventional milling and drilling with subsequent environmental damage incurred during three years of storage. The surface defects themselves could be caused by mechanical damage from conventional machining and handling enhanced by trapped water and machining oil. The lack of significant preferential salt spray attack at these surface defects suggests that the degrease/clean/etch/deoxide steps employed before final conversion coating removed constituents that would lead to failure during salt spray corrosion testing.

Concerning the balance of the components that exist in various stages of completion, we believe that adequate degrease/clean/etch/deoxide steps before further processing will mitigate future concerns about visible defects on the surface of these components. Although the defects will remain on the surface, subsequent coating processes should be adequately conformal to compensate for surface irregularities. If a planar surface is absolutely required, approximately 20-50 μm of aluminum would need to be removed based on the depth of these defects.

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