Effects of Increased Tramp Element Content in Cast Inconel 718

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Alcoa Howmet has observed unintentional increases in tramp elements (Cu, Mn, P, Si, and V) in their IN 718 castings. The tramp elements, typically ~0.1 wt%, are introduced from scrap or contamination during the production process. The individual effects of Cu, Mn, and Si were studied at two concentration levels each compared to a baseline IN 718. Mn had no significant effect on microstructure or mechanical properties. Cu produced a fine equiaxed macrostructure that resulted in a change in mechanical properties. Si decreased stress-rupture life and increased creep elongation.

Project Background

IN 718 is the highest tonnage superalloy worldwide. To reduce cost Alcoa Howmet increased the use of recycled materials in their alloy production, including outsourced or commercially purchased scrap. As a result, an upward trend in tramp element content was observed.

Because tramp elements can be detrimental to performance, this project aims to study how such increases affect microstructure, mechanical properties, castability, and weldability of the alloy. The focus of this study was on the elements Cu, Mn, and Si.

IN 718: Nominal Composition (wt%) [AMS 5383]

<table>
<thead>
<tr>
<th>Element</th>
<th>Al</th>
<th>Co</th>
<th>Cr</th>
<th>Fe</th>
<th>Ni</th>
<th>Nb</th>
<th>Mo</th>
<th>Ti</th>
<th>V</th>
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<tbody>
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<td>Cu</td>
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<td></td>
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<tr>
<td>Mn</td>
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<td>P</td>
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<tr>
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</table>

Results and Discussion

Castability

As-Cast Macrostructure

The baseline displayed a typical macrostructural pattern of radial columnar grains with some equiaxed grains toward the center. Heats with altered compositions were consistent with baseline IN 718 macrostructure, except for 0.17 wt% Cu, which had a fully equiaxed grain structure.

As-Cast Microstructure

All heats presented similar intragranular microstructures with a percentage of microporosity and carbides.

Quantitative Micrography

Immersion density measurements did not show statistically significant differences between compositions. The porosity for all the heats was less than 1 vol.%. The fraction of carbides ranged from 1.5 to 3.5 vol.%. Carbide and porosity fractions were not statistically different from the baseline.

Conclusions

- Cu, Mn, and Si additions up to composition limits do not yield properties below the specification limit.
- Individual effects up to the specification limit are acceptable, however interactive effects are unknown.
- An equiaxed solidification pattern was shown by 0.17 wt% Cu, corresponding to significantly increased RT tensile ductility but slightly decreased stress-rupture life.
- No statistically significant differences in density, porosity, or carbide content were observed.
- If either Cu or Mn concentration increases up to the specification limit, the properties should not be significantly affected.
- If Si is present in concentrations at the specification limit, stress-rupture life may be reduced ~50% with increased elongation.
- No individual element (Cu, Mn, Si) impacted weldability.

Recommendations

It is recommended to conduct a controlled interactional study by iterating the maximum compositional values of Cu, Mn, and Si. For consistency, the same experimental design (castability study, mechanical property testing, and weldability study) should be utilized.

MSE 430-440: Materials Processing and Design