Investigation of Pitting Corrosion Initiation and Propagation of a 316L Stainless Steel Manufactured by the Direct Metal Laser Sintering Process

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Introduction

Direct metal laser sintering (DMLS) is an additive manufacturing process that uses a laser to sinter powdered metal to make geometrically complex parts.

Despite advantages for manufacturing, this process produces microstructural defects called scan tracks as well as porosity.

Those defects can potentially compromise the corrosion resistance of the metal fabricated by DMLS.

Objectives

- Evaluate the pitting corrosion resistance of a 316L SS manufactured by DMLS, using ASTM standards (G5 and G48).
- Investigate the microstructural defects of the 316L SS DMLS (scan tracks) and their relationship to corrosion initiation and propagation.

Hypotheses

"The corrosion resistance of a 316L SS manufactured by the DMLS process is hypothesized to be compromised due to inherent porosity and scan tracks produced during the DMLS process." By heat treatment, the recrystallization of steel grains is promoted and the scan tracks and porosity are "healed" increasing the corrosion resistance of a 316L SS manufactured by the DMLS process.

Electrochemistry

<table>
<thead>
<tr>
<th>Parameters</th>
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<tbody>
<tr>
<td>Solution: 316L SS Cold rolled, 316L SS DMLS</td>
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<tr>
<td>Temperature: 30 °C</td>
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<tr>
<td>Potentiodynamic polarization. Scan rate: 0.167 mV/s from -20 mV wrt OCP up to 1.2 V vs Ag/AgCl</td>
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</tbody>
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Experimental Procedure

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<tr>
<th>Apparatus</th>
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<tr>
<td>pH probe</td>
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<tr>
<td>Luggin Capillary</td>
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<tr>
<td>Counter Electrode</td>
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<tr>
<td>Working Electrode</td>
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<td>Working Electrode</td>
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Results and Discussion

1. 316L stainless steel specimens made by direct metal laser sintering (DMLS) corroded preferentially through the microstructural defects inherent to the manufacturing process (scan tracks).
2. The preferential corrosion can be attributed to voids and porosity on the surface due to the sintering process as well as chemical segregation within the boundaries of the scan tracks.
3. Heat treatment reduced the presence of microstructural defects (scan tracks) in DMLS specimens. Such a condition changed the corrosion damage patterns and the morphology of pits formed.

Future Work

- Investigate the effect of chlorides on the anodic behavior of the DMLS 316L SS.
- Study effects of cold work in combination with heat treatment on the corrosion resistance of the DMLS 316L SS.

Reference


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