Engineered Applications of Electro-Spark Deposition (ESD) for Component Repair

AC9163-5

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**Engineered Applications of Electro-Spark Deposition (ESD) for Component Repair**

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Project Objective

- To determine feasibility of utilizing the ESD process for cost effective repair of components
  - No known method of repair
  - Existing repairs utilize HAZMATS
    - Repair of HAZMAT coatings
  - Current repairs impractical
  - No replacement parts available
Participants

- PEWG
- ESTCP/HCAT
- GEAE
- PW
- Oklahoma City ALC
- NADEP Jacksonville
- NADEP Cherry Point
- NADEP North Island
- Anniston Army Depot
- Corpus Christi Army Depot
- ARL
- AFRL
- NRL
- PNNL
- EWI
- NSWC Carderock
- US Army IEC
- Boeing St. Louis
- Rowan Technology Group
- Dynamics Research Corp.
Project Scope

- ESD repair of Electrolytic Hard Chrome (EHC) coatings
- ESD repair of component substrate materials
Project Methodology - GTE

- Select candidate materials and electrodes
- Optimize ESD parameters for selected substrate/electrode combinations
- Perform materials evaluation and mechanical testing
- Create candidate part screening criteria based on test results
- Develop repair procedures for candidate parts
- Test candidate parts as required
- Implement technology
Repair of EHC - Status

- Work Completed
  - Materials Identified
  - Some materials obtained
  - Some specification identified
  - Some candidate parts identified
  - Most information based upon HVOF
  - JTP
Repair of EHC - Materials

- **Base Materials**
  - IN718, AMS 5663
  - 4340, AMS 6415
  - 17-4PH, AMS 5355

- **Possible Electrodes**
  - Chromium
  - Ni-Chrome
  - Carbides

- **EHC**
  - MIL-STD-1501
    - Supported by QQ-C-320
  - .003” - .015” thickness
Substrate Repair - Status

- Candidate materials selected
- Most material received
- Gathering materials and mechanical testing information
- Beginning process optimization
- Drafting process specifications based upon optimization results
## Substrate Repair - Materials

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Specification</th>
<th>Electrode Specification</th>
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<tbody>
<tr>
<td>IN 718</td>
<td>AMS 5663</td>
<td>AMS 5832</td>
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<tr>
<td>IN 625</td>
<td>AMS 5666</td>
<td>AMS 5837</td>
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<tr>
<td>Hastelloy X</td>
<td>AMS 5754</td>
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<td>AMS 5504</td>
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<tr>
<td>17-4PH</td>
<td>AMS 5604</td>
<td>AMS 5825</td>
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</tbody>
</table>
Substrate Repair - Optimization

- Using DOE approach to optimize ESD parameters
  - Varying Capacitance, Voltage and Current
  - Measuring Deposition Rate, Inclusion %, Bond and HAZ

- Repairs currently underway
  - 50% complete on Hastelloy X
  - 40% complete on IN625
Materials and Mechanical Testing

• Materials Testing
  – Completed prior to mechanical testing
    • Iterative process to assist in ESD optimization
    • Metallurgical evaluations
      – Cracking, Porosity, Inclusions, etc.
    • Bond evaluations
      – Bond buttons, bend testing
  • HAZ
    – Micro-hardness gradients
  • Others ?? (residual stress, element mapping)
Materials and Mechanical Testing

- Mechanical Testing
  - Completed after ESD optimization, materials testing
    - Possible testing includes
      - Low Cycle Fatigue, High Cycle Fatigue (RT & Elevated)
        Tensile, Fatigue Crack Growth, Creep/Stress Rupture,
        Long Term Stability
    - DOE/Specifics needed
    - Definition of defect needed for each instance
ESD Specification & ESD Procedure

- **ESD Specification - Based upon AWS D17**
  - Definition of weld type (repair vs. coatings)
  - Qualification of welder
  - Acceptance Criteria
    - Initially based upon AWS D17, Class A, B & C?
    - ESD specific criteria created during development?

- **ESD Procedure – Based upon AWS B2.1?**
  - ESD equipment parameters
  - Technique description
  - Substrate/electrode/geometry specific
Questions -