National Aeronautics and Space Administration

NASA/ORNL/AFRL project work on EBM LSHR: Additive manufacturing of high-temperature gamma-prime strengthened Ni-based superalloys

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High Temperature Gamma’ Strengthened Superalloys

Work initiated as a CIF, has continued with ARMD, and SLS Engine Office funds

Applications: Rocket Engines, Turbomachinery for commercial & military aircraft

- **Objective:** Expand Additive Manufacturing to high temperature gamma’ superalloys. Overcome the technical barriers due to poor weldability in these alloys.

- **Process:** Electron-beam melting
  - Heated powder-bed for reduced residual stresses and slower cooling rates
  - Multiple beam for faster builds
  - Vacuum for lower risk of contamination

- **Multi-Agency Team:**
  - ORNL- State-of-the art fabrication with in-situ monitoring, Arcam development center on-site
  - NASA GRC (PI)– Powder properties, analytical chemistry, microstructure evaluation, mechanical behavior
  - AFRL– microstructural modeling

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High Temperature Gamma’ Strengthened Superalloys

**Technical Approach:**
- Benchmarking of A.M. feedstock
  - We are using Low Solvus High Refractory (LSHR) disk alloy
- Identify preferred manufacturing pathway
  - Optimization of processing & post heat treatments
- Durability assessment and detailed characterization
  - Differentiate properties of AM from conventional PM and casting technologies

**Long-range vision:**
- Development of new alloys that leverage AM capabilities and mitigate cracking
  - May extend beyond gamma-prime strengthened...
- Tailored material properties for light weight and durability
  - Chemistry and microstructural gradients.

<table>
<thead>
<tr>
<th>Location</th>
<th>Key Property</th>
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<tbody>
<tr>
<td>1500 °F rim</td>
<td>Need high creep life and crack growth resistance</td>
</tr>
<tr>
<td>1300 °F web</td>
<td>Creep/fatigue interaction</td>
</tr>
<tr>
<td>800 °F bore</td>
<td>Need high tensile strength and low cycle fatigue life</td>
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Test Specimens built at ORNL

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