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About Me

• **National Energy Technology Laboratory**
  • Deloitte Consulting: onsite support contractor
  • R&D and Technology Commercialization Strategy

• **New Pig Corporation**
  • Director, New Product Development & Product Strategy
  • Agile Product Development, Human-centered design, Web-as-lab strategies

• **Kennametal Inc**
  • Strategic Technology Manager
  • New-to-company technology and market
    – Advanced Manufacturing
    – High-performance Materials
Advanced Ultra-supercritical (AUSC)

Next generation power generation

<table>
<thead>
<tr>
<th>Steam Conditions</th>
<th>Subcritical</th>
<th>Supercritical (SC)</th>
<th>Ultra-supercritical (USC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Plant Efficiency (HHV)</td>
<td>2400 psig, 535 – 550 °C</td>
<td>38%</td>
<td>&gt;42%</td>
</tr>
<tr>
<td></td>
<td>&gt;3600 psig, 550°C</td>
<td></td>
<td>&gt;3600 psig, 600°C</td>
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</tbody>
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AUSC power plants require less coal per megawatt-hour, leading to lower emissions, higher efficiency and lower fuel costs per megawatt.

Source: https://www.netl.doe.gov/sites/default/files/2017-11/Crosscutting_20150429_0830A_EIO.pdf
The commercialization of AUSC power generation technology will benefit the environment and reduce energy costs compared to existing coal-fired power generation plants.
DOE Investing in AUSC Supply Chain

ComTest Program Working Towards AUSC Demo

ComTest Program

- Led by Energy Industries of Ohio (EIO)
- Actively focused on establishing a capable domestic supply chain of nickel superalloy AUSC components:
  - Boiler headers, tubing assemblies
  - Turbine rotors, nozzle carrier
- Alloys:
  - Inconel 740H
  - Haynes 282
Commercialization Challenges

Enabling technology is required to bring AUSC to market

Advanced Ultrasupercritical steam conditions force large plant components to be fabricated from new metal alloys to withstand the temperatures and pressures

Challenges:
- **TECHNICAL**: Establishing a capable manufacturing processes needed to manufacture these large superalloy components
- **ECONOMIC**: Making technology available at a cost that ensures market adoption

<table>
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<tr>
<th>Existing Components</th>
<th>New AUSC Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel (eg T22)</td>
<td>Ni-super alloy</td>
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10X Cost Increase

Pound for pound
Goal: Identify opportunities to reduce cost in the supply chain

AUSC Component Fabrication

- Alloy Production
- Intermediate Component Shaping
- Final Component Shaping
- Component Post Processing
- System Assembly

1. New Custom Alloys
   - Melt/Re-melt
   - IN740H
   - H282

2. Existing Superalloys
   - Casting
   - Forging
   - Tubes & Header Pipes
   - Finish Machining
   - Heat treatment
   - Welding
Path 1: Alloy Design Cost Estimation

Understanding tradeoffs between cost and performance

**OBJECTIVE:** Develop a more robust cost model to help guide alloy development by making cost trade-offs in alloy composition more apparent.
Path 2: Existing Alloy Fabrication

**Identify cost and technical challenges related to IN740 & H282**

**Objective:** Identify the major sources of cost in the production process of existing AUSC superalloy component designs
Cost Reduction Opportunities

Large-sized tubular components represent biggest opportunity

- Tubular components represent the largest share of superalloy parts in AUSC plant designs – roughly 60-70%
- The large size and diameter/wall thickness ratio present challenges for conventional extrusion methods
- Only one domestic fabricator with large enough extrusion press
- Cost reduction and sourcing flexibility could be achieved with seam-welded tube and pipe

Seam-welded pipes and tubes will reduce cost, but must overcome industry reluctance to adopt due to product failure concerns
Near-net shaped fabrication methods may reduce cost

Valve body sand casting performed by Haynes International as part of the ComTest program:

- \( \frac{1}{2} \) of the valve body:
  - Pour size: 17,500 lbs
  - Component size: 6,000 lbs

Potential to use alternative fabrication methods like powder metallurgy for greater efficiency?

Additive manufacturing or other near-net shape powder metallurgy production methods may yield cost savings compared to casting.
Field sites uncover technology challenges

- Known AUSC Ni-superalloy components technology development challenges:
  - Larger size components
  - Welding dissimilar materials
- Uncovering new challenges: Going from test to field trials
- ComTest project plans AUSC demonstration by 2025
- Opportunities to test and learn sooner?

New challenges will not be known until components are fabricated and tested in field sites at system-integration stage
Summary

Facilitating AUSC technology adoption

• The goal of our work is to uncover opportunities for focused R&D activity to lower the cost of nickel superalloy components.

• Initial research conducted with industry interview uncovered three potential areas for DOE investment for IN740H & H282 alloys:
  1. **Seam-welded tubing**: Demonstrate fabrication and risk assessment & testing
  2. **Near-net shape production** methods leveraging PM and/or AM
  3. **System-level testing**: Identify and fund the fabrication and testing of components in comparable environments

• **New alloy development**: Longer term. Continue development of tools to help researchers understand trade-offs between alloy design and cost.