

2ND ANNUAL **ENERGY & INNOVATION** CONFERENCE

Materials Design & Development Advanced Alloy Fabrication

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Technology or Capability Overview

- Computer Modeling for Alloy Design & Life Prediction
- Melting, Casting, Fabrication & Heat Treatment
- Environmental Characterization
- Mechanical Testing & Evaluation
- Microstructure Characterization & Analysis

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Melting and Fabrication Facilities

At NETL Laboratories

Button Furnace – Up to 500 grams

Vacuum Induction Melting – Up to 200 lb

Vacuum Arc Remelting - Up to 400 lb

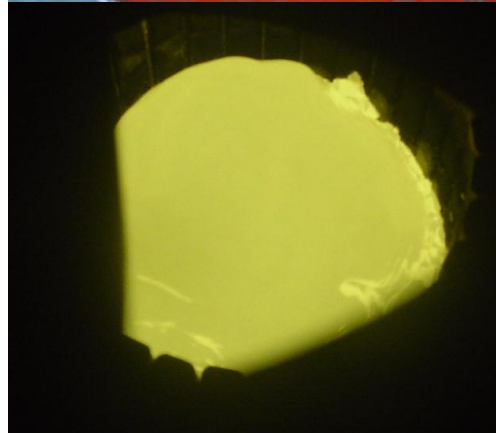
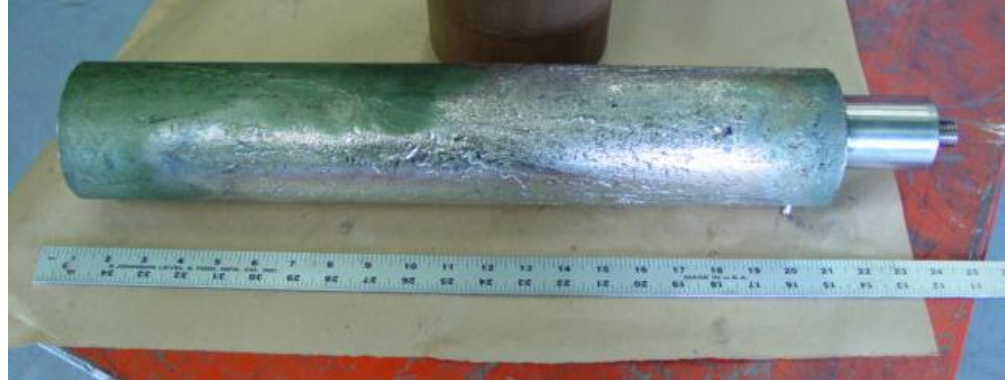
Electroslag Remelting - Up to 400 lb

Air Induction Melting – Up to 300 lb

Directional Solidification - Up to 200 lb

Induction Skull Melting - Up to 50 lb

Vacuum Heat Treating – Up to 1650° C



Melting and Fabrication Facilities

At NETL Laboratories

Preheat – Up to 1500° C; 3 x 3 x 6 ft³

Press Forge (500 Ton)

Hot Rolling (420 Ton)

Cold Rolling (750 Ton)



Industry Significance

Significance of Working wit NETL-RUA:

– Cost Savings

- Targeted approach to problem
- Specific technical resources available
- Focused work on problem at hand

– Process Improvements

- Expertise in understanding “*Alloy Design-Manufacture-Microstructure-Mechanical/Environmental Behavior-Life Cycle*” and how to effect those changes in real materials

– Extended Life

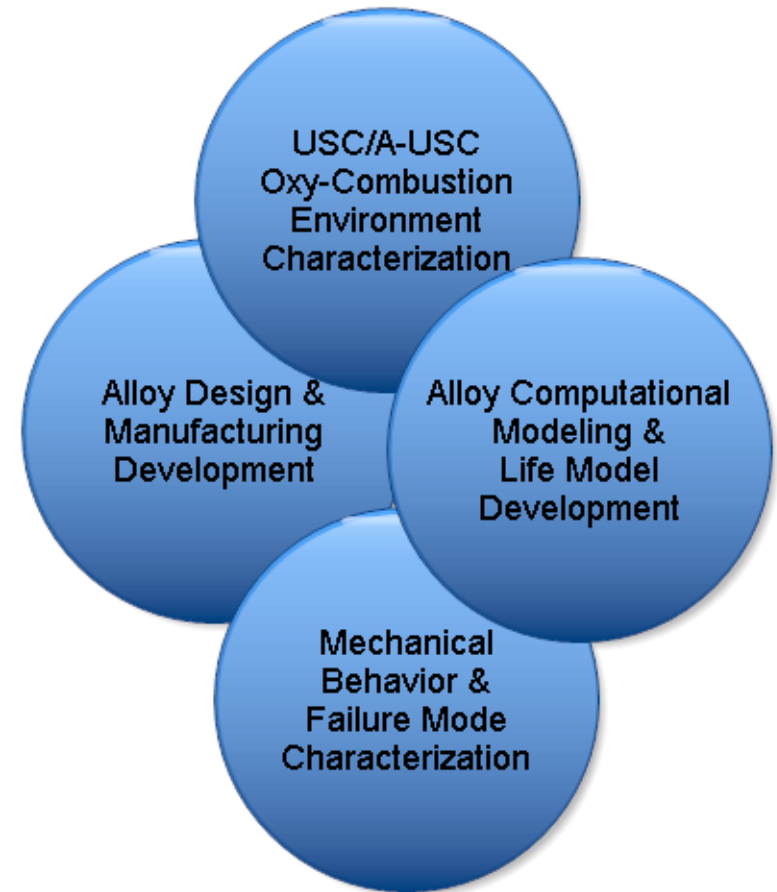
- Application of computer modeling & simulation benchmarked against experimental data

Applications

- Internal NETL Technology Focus: Design, fabricate & analyze materials for a wide variety of FE applications:
 - SOFC
 - Gas Separation Membrane
 - Advanced Combustion Boiler & Steam Turbine
 - Land-base Gas Turbine
- Assist External Customers in Targeted Materials Problems:
 - Alloy Design/Chemistry Formulation
 - Fabrication & Heat Treatment
 - Understanding Mechanical Behavior
 - Evaluating Environmental Interaction

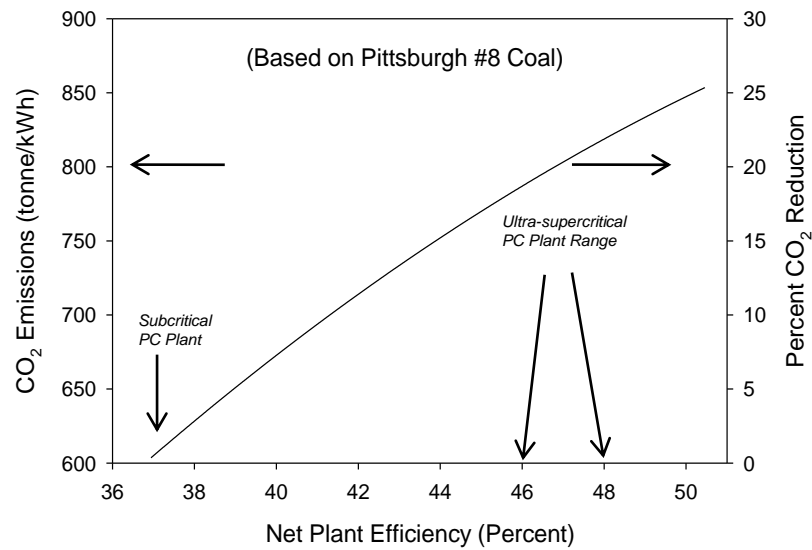
Advanced Combustion: Overall Approach

- ❑ Integrated multi-scale computational approach, complimented with a focused experimental program, emphasizing the design & optimization of materials for advanced FE combustion systems.
 - *Computational material design & optimization.*
 - *Lab-scale synthesis of materials.*
 - *Mechanical & chemical assessment of materials performance in real environments*
 - *Simulation of component life in conventional & oxy-fuel combustion environments.*



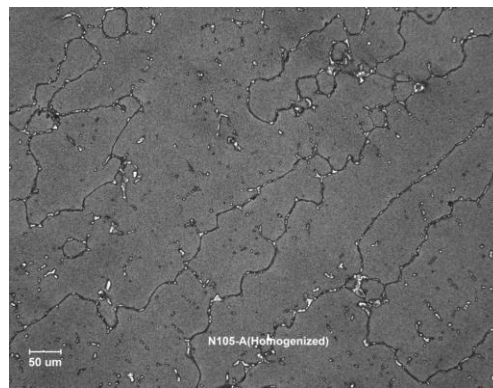
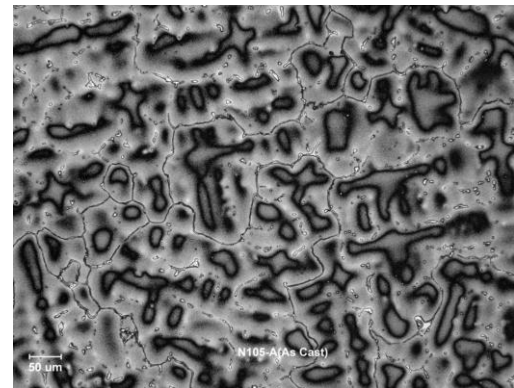
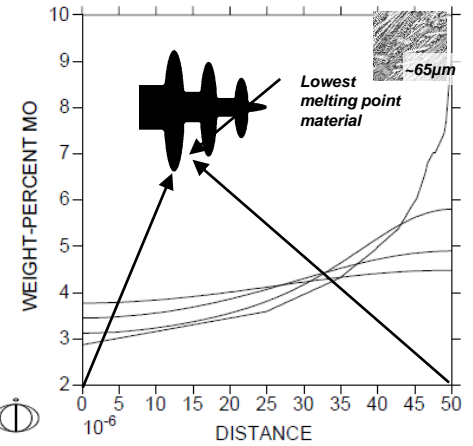
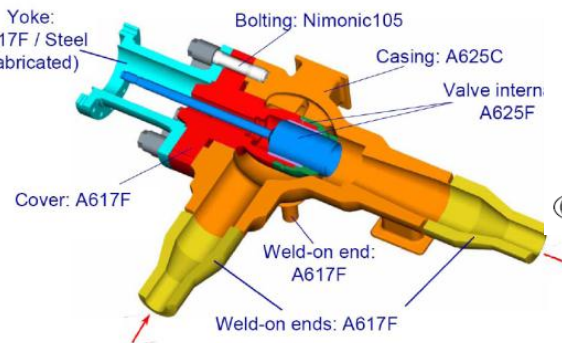
Large Ni-Base Castings

Developing Materials/Processes for Reduced CO₂ Footprint



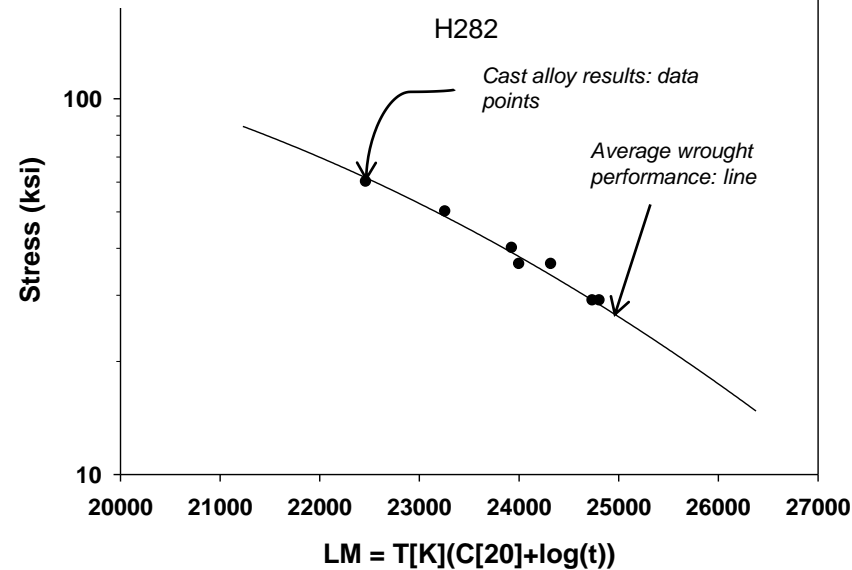
Castings

- 1-15 tons
- Up to 200 mm thick



As-Cast

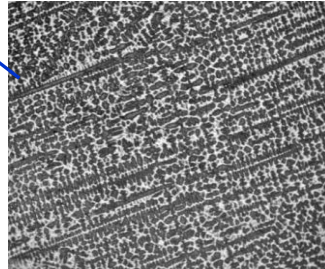
Homogenized



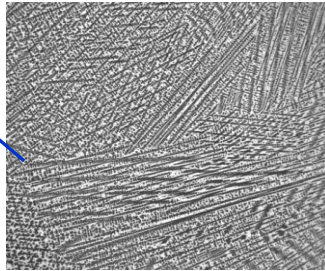
Secondary Dendrite Arm Spacing (SDAS) in Larger Casting



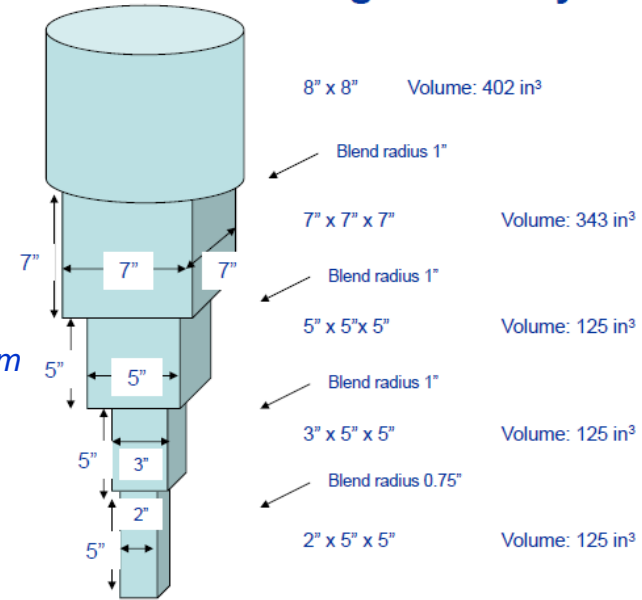
Riser Pad SDAS: 154-188 μm



Keel Block SDAS: 67-57 μm



Casting Geometry



Interaction With Manufacturers

Homogenization Activities



ESR Ingot

Special Metals ESR/VAR Ingot of Haynes 282



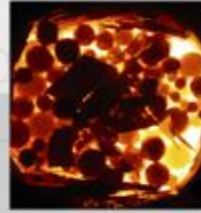
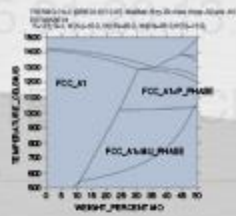
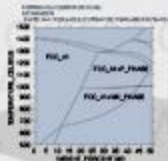
VAR Ingot: 24" (dia.) x 71" (length); ~10,000#

- NETL Small Ingots (15#): 1100°C/3 h + 1200°C/9 h
- METALTEK Step Block (300#): 1130°C/3 h + 1200°C/3 h + 1210°C/14 h
- FLOWERVE Step Block (1000#): 1100°C/6 h + 1200°C/48 h
- Special Metals ESR/VAR (10,000#): 1133°C/4 h + 1190°C/8 h + 1223°C/30 h

Partnership Opportunities

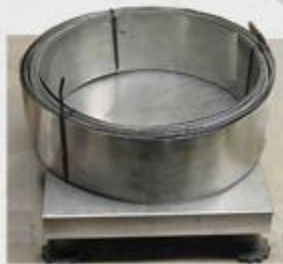
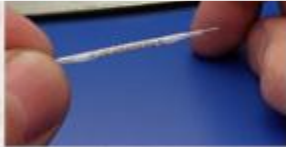
- Is this technology or capability part of a current research project?
- Are we looking for CRADA partner, licensing opportunity?
- Are we looking for funding?
- Do you want a place to demonstrate the technology?
- Is there possible applications of this capability that could assist industry to solve their challenges?

Advanced Fabrication Activities



Development Rational:

- *Performance, cost & application driven*
- *Use of computer modeling*
- *Prototype alloys ranging from ~100 g to 100 kg*



Recent customers include:

- *DOE funded projects including SOFC & high temperature FE materials development*
- *Alloys for medical stent applications*
- *Alloys for Shell*
- *Alloys for ORNL*
- *Alloys for GE*
- *Alloys for P&W*



Benefits to Partner

- Benefits of partnering with NETL-RUA:
 - Access
 - Expertise
 - Facilities
- Resources available for technology development
 - Computer modeling & simulation
 - Intermediate scale metal production
 - Mechanical & environmental exposure
 - Microstructural characterization & analysis

NETL Alloy Design & Manufacturing Success Story

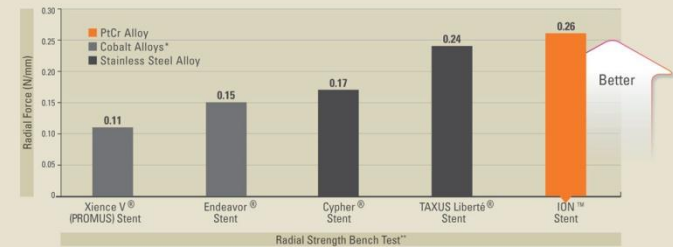
Medical Stent Alloy



RD 100 Award, 2011
FLC Outstanding Commercialization Success, 2012
The Secretary's Achievement Award, 2012

Boston Scientific's platinum/chromium coronary stent series, which includes the PROMUS® Element™, ION™, and OMEGA™ Stent Systems, has become the leading stent platform in the world, with more than \$4 billion in sales. The stent series has captured a 45 percent market share in the United States, and a 33 percent global share of the coronary stent market. The new stent series has resulted in the creation of 300 new jobs at Boston Scientific, with an additional 150 new jobs created in its distribution network and alloy producer, all of which are located in the US.

Radial Strength Bench Test**



* The alloy of the Endeavor Stent is cobalt nickel. The alloy of the Xience V (PROMUS) Stent is cobalt chromium.
 ** Based on internal bench tests conducted by Boston Scientific Corporation: 2.5 mm, ION Stent N = 15, Xience V Stent N = 10, Cypher Stent N = 3, TAXUS Liberté Stent N = 10, Endeavor Stent N = 7.
 Bench test results may not necessarily be indicative of clinical performance.
 Testing completed by Boston Scientific Corporation. Data on file.

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