CRADA NFE-08-01671 – Materials for Advanced Turbocharger Design

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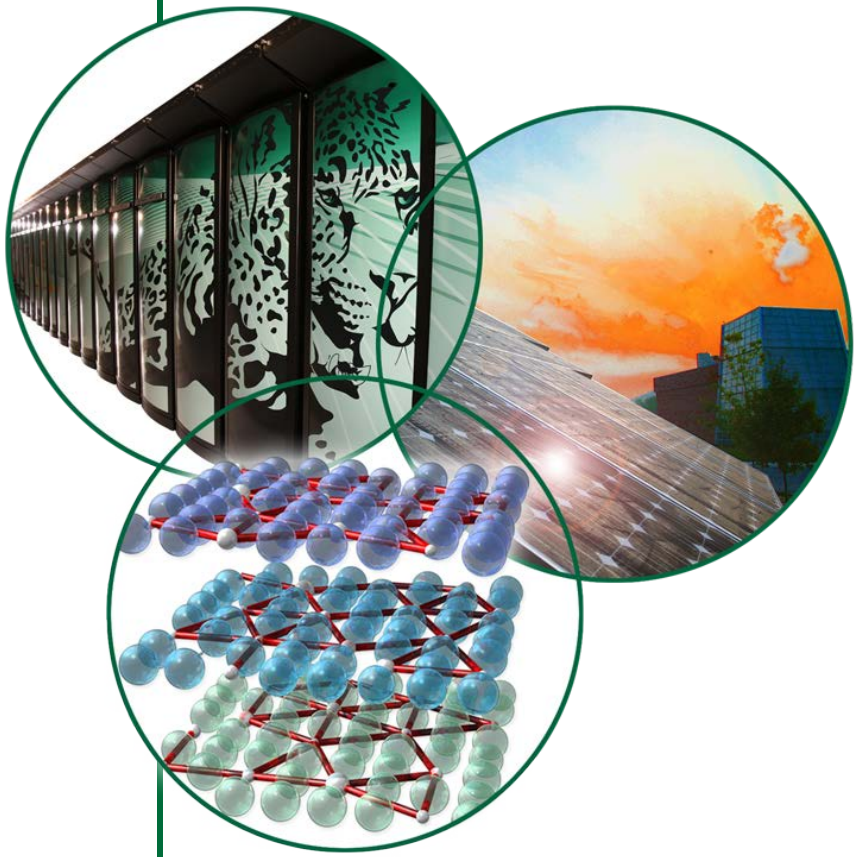

Project ID – PM038

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U.S. DEPARTMENT OF ENERGY

Honeywell

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Overview

Timeline

- Project began – September, 2009
- Project ends – September, 2012
- Project is <66% complete, and extension will be negotiated with Honeywell this year due to expanded commercialization opportunities

Budget

- Total Project Funding
  - DOE Share – 50%
  - Honeywell – 50%
- FY11 Funding - $300,000
- FY12 Funding - $300,000

Barriers

- **Barriers addressed include:**
  - Difficulty in simultaneously increasing efficiency and reducing emissions
  - HECC Technologies increase exhaust temperatures for turbochargers

Partners

• Honeywell's suppliers for turbocharger components
• Engine customers for turbochargers

Objective

This CRADA project is relevant to a key technical gap in Propulsion Materials that supports the following Advanced Combustion Engine goal:

2015 Commercial Engine – Improve Efficiency by 20% over 2009 baseline efficiency

Technical Objective – Higher temperatures (>750^{o}C, diesel, >950^{o}C gasoline) exceed the strength and temperature capability of current materials, particularly cast-iron for turbocharger housings

Impact – Turbocharger housing and other components with more temperature capability and strength will enable higher, sustained operating temperatures. Stainless steel turbo-housings will also reduce weight and retain exhaust heat relative to cast-irons

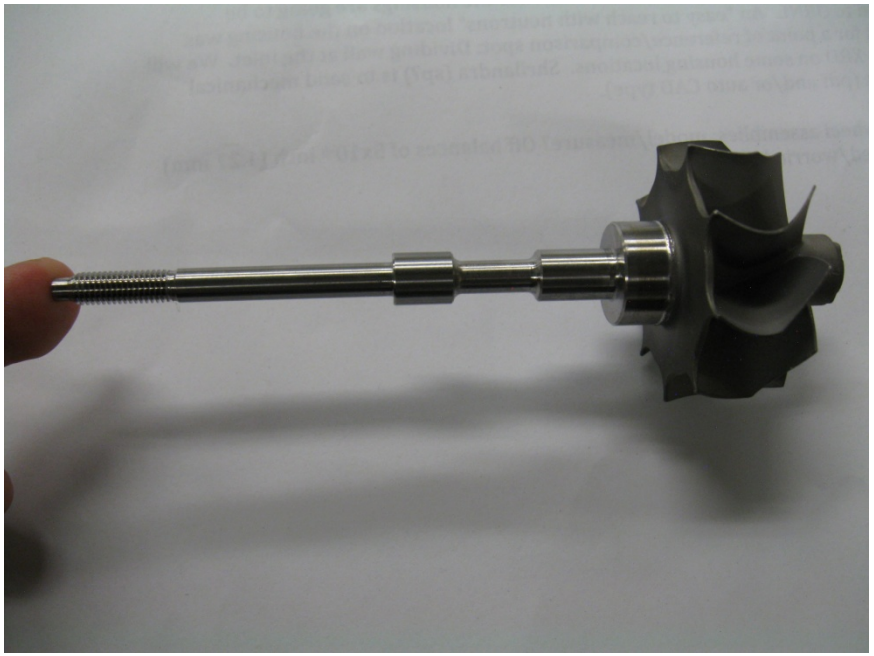
Approach

- Honeywell and ORNL have considered current materials used for hot (turbine) and cold (compressor) portions of current turbocharger systems
- Honeywell and ORNL have identified turbocharger housings and turbine-wheel/shaft assemblies as priority components for consideration with increased exhaust temperatures
- Cast austenitic stainless steels have more temperature capability as turbocharger housings than cast-irons
- Weld-joints between steel shafts and Ni-based alloy turbine wheels are the focus of residual stress studies

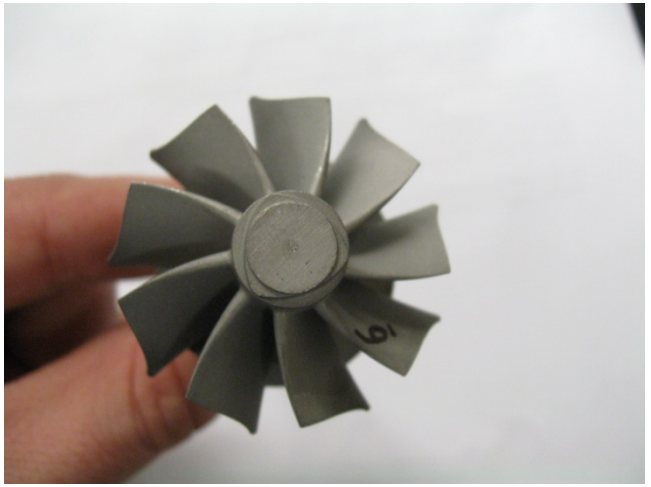
Milestones

- FY2012 – complete neutron-scattering residual-stress measurements on wheel/shaft assemblies (Dec, 2011, done)
- FY2012 – complete creep-rupture of aged cast CF8C-Plus stainless steels (April, 2012, on-track)
- FY2012 – Extend CRADA (August, 2012, on-track)

Technical Accomplishment – HFIR Neutron Scattering on wheel/shaft assemblies



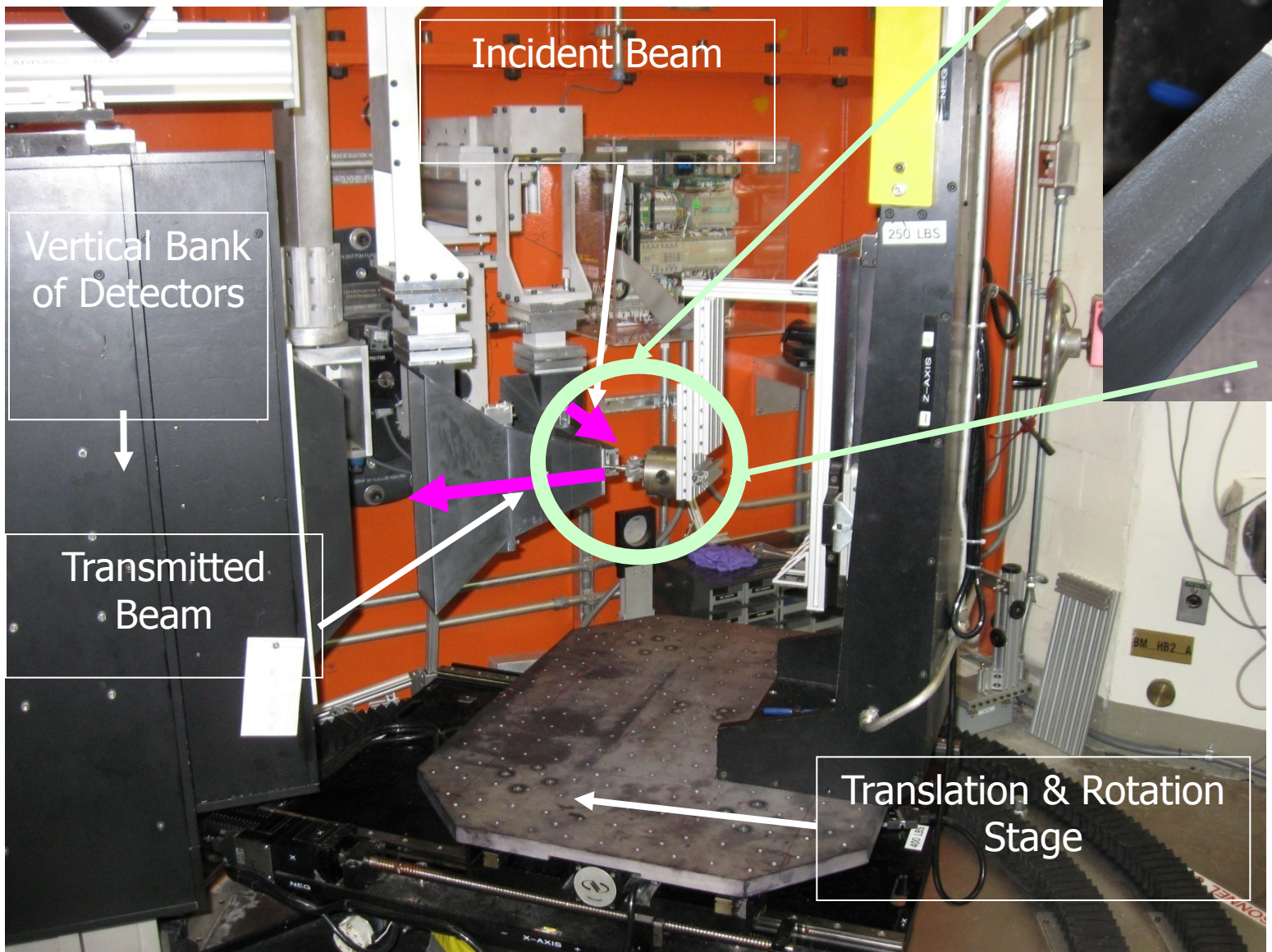
Honeywell supplied wheel/shaft components from gasoline turbocharger products

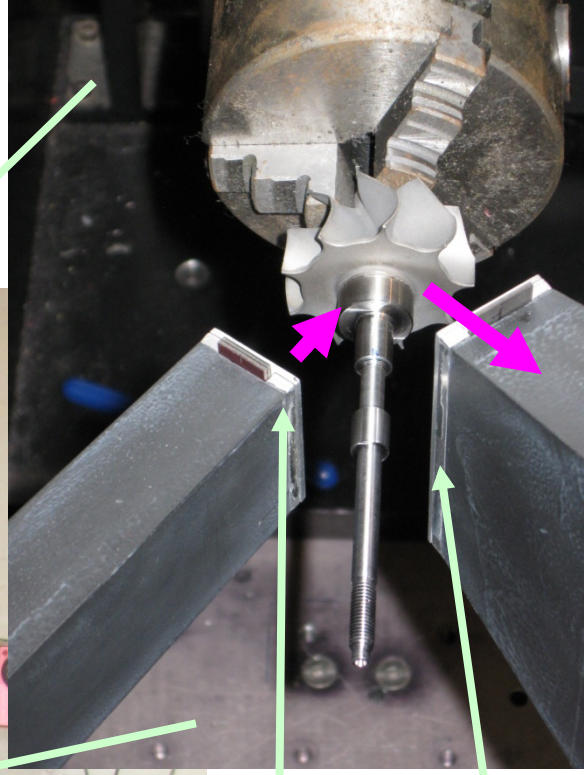


HTML User-Center at ORNL used neutron-scattering to measure residual stresses in the weld-joint between Ni-based superalloy wheel and steel shaft

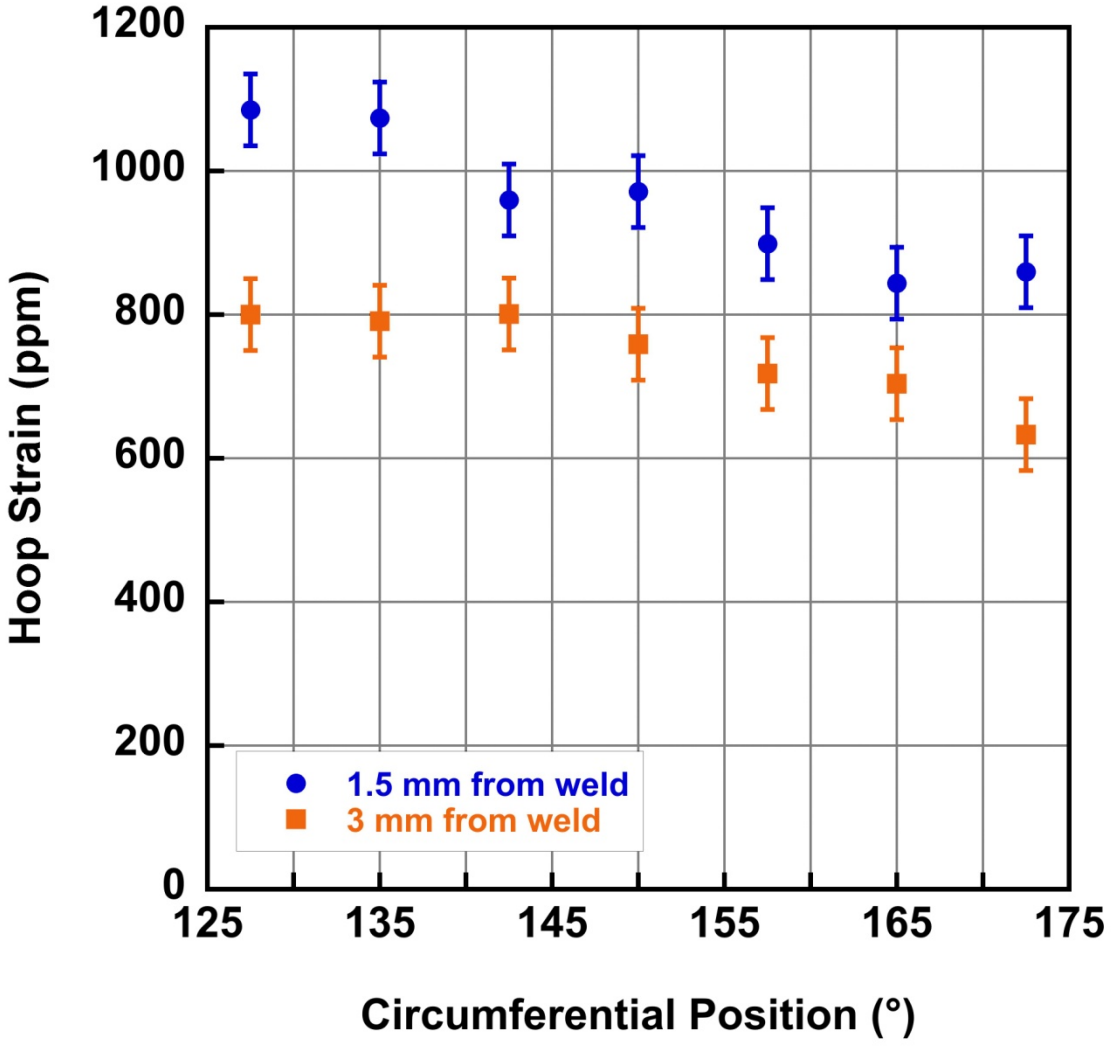
html
HIGH TEMPERATURE MATERIALS LABORATORY

Technical Accomplishments – Initial neutron-scattering experiments done at NRSF2





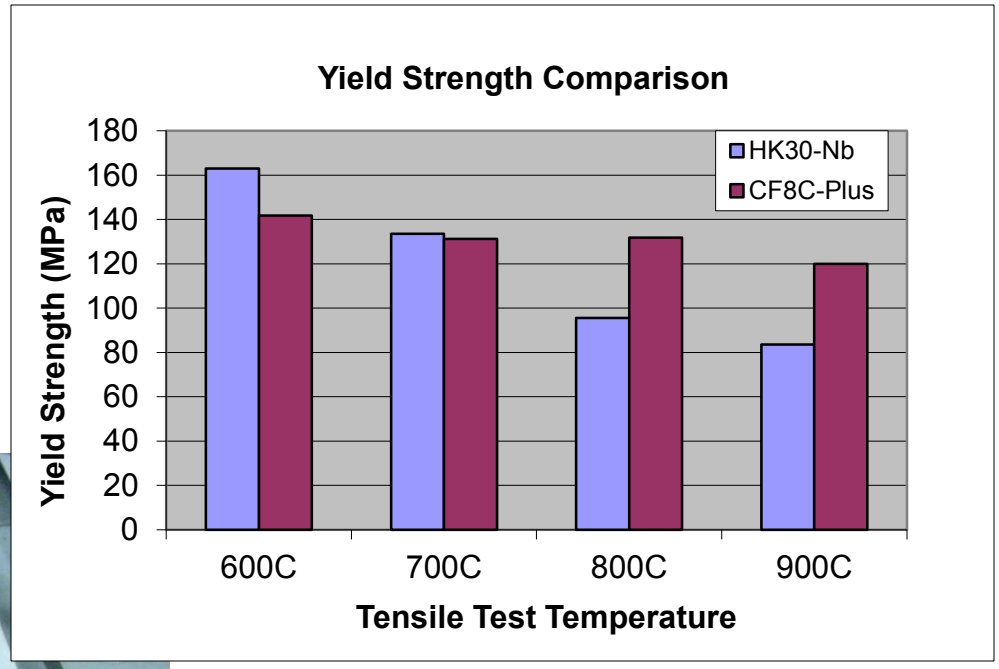
Neutron scattering shows an assymetric tensile hoop strain



Technical Accomplishments – Upgrade Turbo-Housing to Cast Stainless Steel

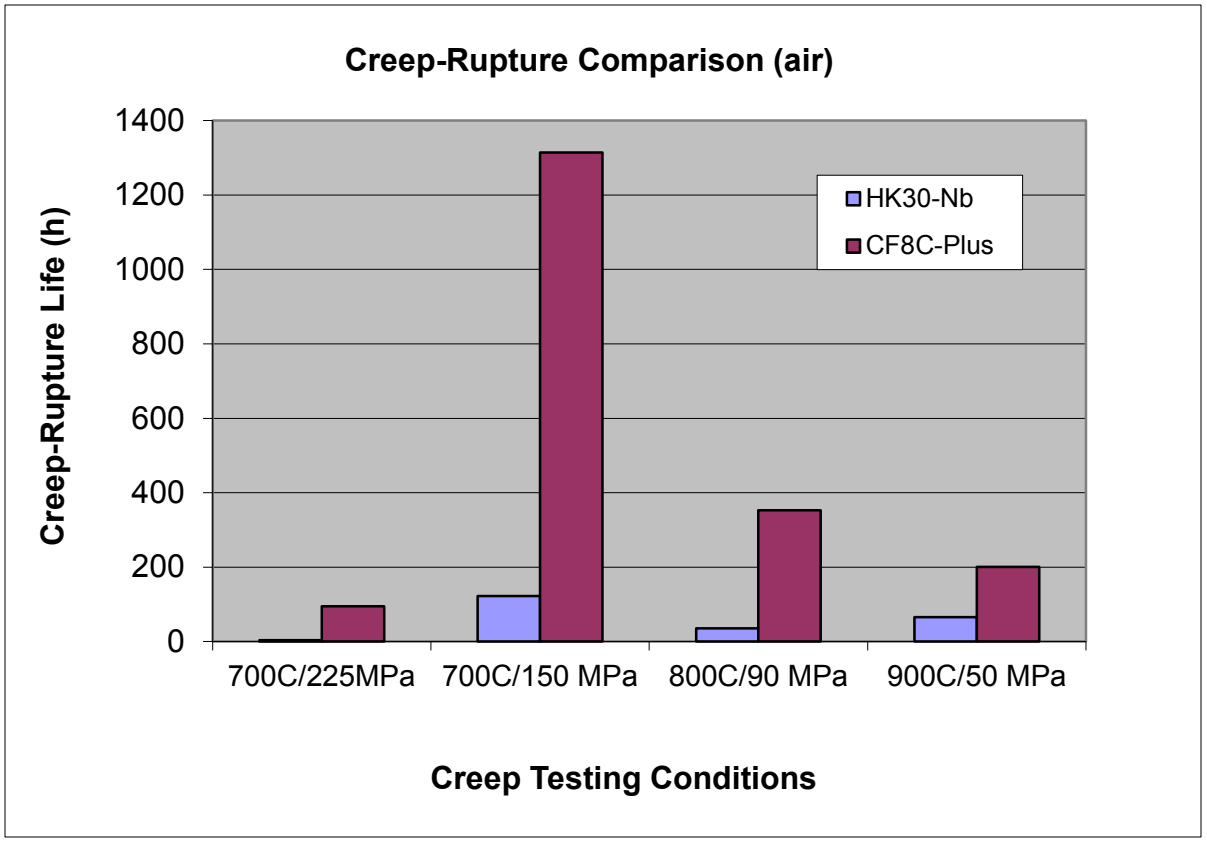
ORNL developed CF8C-Plus cast stainless steel with more strength than HK30Nb stainless alloy > 750°C.

Both have much more strength than SiMo cast-iron above 500-600°C



Current SiMo cast-iron turbocharger housing for diesel engine product

Technical Accomplishments – Upgrade Turbo-Housing to Cast Stainless Steel for More High-Temperature Creep Resistance



Creep-Rupture Testing of Cast CF8C-Plus stainless steel and HK30-Nb stainless alloy at ORNL

- CF8C-Plus cast stainless steel has significantly better creep-resistance than HK30-Nb stainless alloy at 700-900^{o}C
- CF8C-Plus stainless steel cost is about 33% less than HK30-Nb alloy

Collaboration and Coordination with Other Partners

- Honeywell has identified a commercial application of CF8C-Plus for turbohousings with Ford on the V-6 3.5L Ecoboost turbocharged gasoline engine used on light trucks
- ORNL provides substantial collaboration between this project and Residual-Stress User Center at the High Temperature Materials Laboratory (HTML) for neutron-scattering experiments at HFIR (T. Watkins)

Future Work – Produce stainless steel turbo-housings, test materials for other components and continue residual stress experiments

- Honeywell will work with stainless steel foundry to produce turbocharger housings of CF8C-Plus steel
- Expand properties testing for turbine housing and wheel alloys to include oxidation and fatigue

Summary

- Honeywell and ORNL have initially assessed the effects of higher exhaust temperatures on turbocharger materials and components, and prioritized several for more in-depth study
- Residual stresses in weld-joints between Ni-based alloy turbine wheels and steel shafts are a concern that has been addressed with neutron scattering experiments on wheel/shaft components at the HTML at ORNL
- Long-term creep-rupture data has shown that CF8C-Plus cast stainless steel has more performance than HK30-Nb stainless alloy as an upgrade for turbo-housings at 700-900^{o}C