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°C, diesel, >950°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
Technical Accomplishments – Initial neutron-scattering experiments done at NRSF2
Neutron scattering shows an asymmetric 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

- CF8C-Plus cast stainless steel has significantly better creep-resistance than HK30-Nb stainless alloy at 700-900°C

- CF8C-Plus stainless steel cost is about 33% less than HK30-Nb alloy

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