• New Austenitic Stainless Steels for Exhaust Components (Agreement 9112)
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  – Oak Ridge National Laboratory, Oak Ridge, TN
  – Tuesday, Feb. 26, 2008, morning session

“This presentation does not contain any proprietary or confidential information”
Purpose of Work

• This ORNL/Caterpillar CRADA project (3y + 4y extension) was defined to first develop, and then to commercialize CF8C-Plus cast stainless steel to provide higher temperature capability and reliability for advanced diesel engine exhaust components

• This CRADA will expire in July, 2008
Barriers – FY2008

- Technical Barriers – Verify the long-term benefits of CF8C-Plus cast stainless steels, and the upper temperature limits, for various diesel engine exhaust component applications

- Commercialization Barriers – Provide investment-grade patent portfolio, attract and interact with major industrial customers, and provide the data that shows CF8C-Plus steel works for their applications
Approach – Alloy Development

- ORNL and Caterpillar developed cast CF8C-Plus steel using the “engineered microstructure” approach.
- CF8C-Plus steel was an “instant” success, with all first-heat, first-test results being fantastic. CF8C-Plus won a 2003 R&D 100 Award.
- CF8C-Plus was extensively tested to qualify it for diesel exhaust component applications.
- CF8C-Plus Cu/W was developed to push strength even higher at 750-900°C.
Approach – Commercialization

• Caterpillar pursued initial diesel engine component applications

• ORNL generated short and long term creep and fatigue data, and metallurgical understanding to support CAT and non-CAT commercial applications

• CAT and ORNL work together to attract industrial end-users for commercial licensing, work with stainless steel foundries to support prototype trials, and generate needed mechanical properties data
CF8C-Plus cast stainless steel was developed as an upgrade for current exhaust alloys.

SiMo cast iron turbocharger-housing

SiMo cast iron Exhaust manifold

C-15, 14.6L HD On-Highway Diesel Engine
CF8C-Plus Cast Stainless Steel won a 2003 R&D100 Award

Outstanding Creep-Rupture Strength at 550-850°C

1st commercial heats only 1.5y after initial lab-scale heat

LMP (Larson-Miller Parameter) is calculated using creep-rupture time and temperature
Technical Accomplishments - CF8C-Plus Steel Offers Creep Resistance Comparable to Superalloy 617 at the Cost of Stainless Steel
Technical Accomplishments - CF8C-Plus Cu/W has even more creep resistance at 750-850°C
Technical Achievements - CF8C-Plus Steel Has Excellent Castability for Defect-Free Parts. CF8C-Plus Steel Requires No Additional Heat-Treatments

CF8C-Plus Fluidity Spiral

Fluidity

Better

Stainless Foundry & Engineering – Milwaukee, WI
Technical Accomplishments - Caterpillar began using **CF8C-Plus steel** for the CRS components on all heavy-duty highway truck diesel engines in January, 2007.

- **Exhaust combustor** (turbo exhaust + injected fuel) to clean out particulate filters: high temperature and rapid cycling conditions
- To date over 1 million lbs of CF8C-Plus steel have been cast for just this one application.
Technology Transfer

- Caterpillar and ORNL have 1 U.S. Patent (7,153,373 B2, Dec. 26, 2006), 1 U.S. Patent-pending, and foreign-filings pending, to support commercial licensing interest

- ORNL and Caterpillar have applied for ASTM new alloy grade for CF8C-Plus steel, to support commercial licensing interest

- A major turbocharger OEM and a major gas-turbine OEM began licensing activities with Caterpillar in 2007 for CF8C-Plus steel
In May, 2007, **CF8C-Plus** was submitted to ASTM for approval of a new heat-resistant cast alloy grade – **HG10MNN**

Welds of CF8C-Plus passed U-bend Ductility test

Welds of CF8C-Plus passed RT tensile tests for UTS and ductility, with 20% Better YS than base metal
FY2008 Activities – Pursue Commercial Licensing for Turbocharger Application

- In FY2008, ORNL and Caterpillar have been interacting with a major turbocharger OEM to consider commercial licensing of CF8C-Plus as a performance/capability upgrade for SiMo cast-iron.
- In FY2008, ORNL was awarded $500,000 by DOE/EERE Technology Commercialization and Development Program to support the turbocharger application.
ORNL is using *step-castings of CF8C-Plus* to measure mechanical properties of thin sections representative of heavy-diesel exhaust components.
Patents (2006-2007)
