CF8C-Plus: A New Cast Stainless Steel for High-Temperature Diesel Exhaust Components

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CF8C-Plus cast stainless steel was developed to provide higher temperature capability and reliability for advanced diesel engine components.

- Cast stainless upgrade for SiMo cast-iron diesel engine exhaust components
Materials Need: High Performance Low-Cost Alloy was Needed to Replace SiMo Cast Iron

Some Candidate Alloy Compositions (wt%)

- SiMo Cast Iron: Fe-3.45C-4Si-0.6Mo-0.3Mn
- CF8C: Fe-19Cr-10Ni-0.07C-1.0Nb-0.7Mn-1Si
- CF8C-Plus: Fe-19Cr-12Ni-0.07C-0.07Nb-0.4Si-+Mn+N
- Ni-Resist: Fe-2Cr-35Ni-0.5Mn-5Si-1.9C

Improving the properties of less expensive alloys without the costly addition of Ni offered the best opportunity

CF8C-Plus = Best Results
Alloy Development: Mn and N were the “Plus” added to improve austenite stability

- Lower cost Mn and N were added instead of costly Ni for fully austenitic stainless steel
- CF8C = 15-25% Delta Ferrite, CF8C-Plus = 0% Delta Ferrite
CF8C-Plus Cast Stainless Steel won a 2003 R&D100 Award for Outstanding Heat-Resistance at 850°C, and Successful Commercial Scale-Up in only 1.5 years.

Creep-Rupture at 550-850°C

LMP (Larson-Miller Parameter) is calculated using creep-rupture time and temperature.
Engineered Microstructure

- CF8C-Plus Has “Super” Creep Resistance at 850°C Because Abundant, Stable Nano-NbC Precipitates Pin Dislocations

Creep Tested 850°C/23,000 h

(TEM, as cast)
CF8C-Plus Has Great Castability for Defect-Free Parts

**Fluidity**

- **CF8C-Plus (<0.5Si)** shows as-good or better fluidity compared to **CF8M (1.5Si)** at equivalent pour temperatures

*From Ron Bird, Stainless Foundry and Engineering*
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 (SF&E)

Welds of CF8C-Plus passed RT tensile tests for UTS and ductility, with 20% Better YS than base metal
Commercial Applications – Direct Replacement of NiResist for Natural Gas Reciprocating Engines at Reduced Cost *(Cost of CF8C-Plus = 80% of NiResist)*

45 lb static sand-cast **CF8C-Plus** exhaust component cast by Stainless Foundry and Engineering, Inc.
Caterpillar is now using **CF8C-Plus steel** for the CRS components which are on all heavy-duty highway truck diesel engines in 2007.

- Exhaust combustor (turbo exhaust + injected fuel) to clean out particulate filters: high temperature and rapid cycling conditions.
New Work on Step-Castings to get mechanical properties data on thin-sections, to support turbocharger and manifold applications
ORNL is using step-castings of CF8C-Plus and CF8C-Plus Cu/W to measure mechanical properties of the thin sections representative of heavy-diesel exhaust components.

- Stainless Foundry & Engineering made step castings of CF8C-Plus and CF8C-Plus Cu/W in late 2006.
Thin Sections of **CF8C-Plus** have refined dendrite/grain structure
CF8C-Plus thin sections have YS as good or better than thicker sections.
Preliminary data indicates **CF8C-Plus thin-sections** also have good creep and rupture resistance.
CF8C-Plus Cu/W has improved creep resistance compared to CF8C-Plus

- Good creep resistance in thin-section casting is important for turbocharger and manifold applications.
Conclusions for New CF8C-Plus cast austenitic stainless steel

• Castable, even as thin sheets
• Weldable
• Outstanding Creep Performance
• Cost-Effective
• Applications
  – Caterpillar CRS components (on-highway in 2007)
  – Exhaust components for NG engines
  – Turbocharger housings
  – Numerous other potential spin-offs