

# Cast Alumina-Forming Austenitic Stainless Steel for High Temperatures, Corrosive Environments

UT-B ID 201002503, 201102669



## Technology Summary

Cast alumina-forming austenitic (AFA) stainless steels have alloy compositions suitable for castings that have superior high-temperature oxidation and creep resistance in a range of energy production and chemical processing applications. Conventional high-temperature stainless steels rely on chromium oxide (chromia,  $\text{Cr}_2\text{O}_3$ ) surface layers for protection from high-temperature oxidation. Cast AFA alloys comprise aluminum at a weight percentage sufficient to form protective aluminum oxide (alumina,  $\text{Al}_2\text{O}_3$ ) surface layers and have superior corrosion resistance because of several advantages of alumina over chromia surface layers.

Alumina grows at a rate 1 to 2 orders of magnitude slower than chromia and is also significantly more thermodynamically stable in oxygen, which results in fundamentally superior high-temperature oxidation resistance. An additional key advantage of alumina is its greater stability in the presence of water vapor. Water vapor is encountered in most high-temperature industrial environments, such as in gas turbines, combustion, fossil-fired steam plants, and solid oxide fuel cells. Compromised oxidation resistance of chromia in the presence of aggressive species such as water vapor, carbon, sulfur, etc., typically encountered in energy production and process environments, necessitates a reduction in operating temperature to achieve component durability targets. This temperature reduction reduces process efficiency and increases environmental emissions.

Developed by researchers at Oak Ridge National Laboratory, cast AFA stainless steels are a new class of high-temperature (600°C–1,100°C, depending on grade) structural alloy steels designed for optimal properties in as-cast components. These patented new alloys (US Patent 8,431,072 B2) and patent-pending alloys have been developed to replace cast chromia-forming austenitic stainless steels for use in corrosive high-temperature environments encountered in energy production and chemical/petrochemical processing and cast irons and stainless steels in higher performance automotive exhaust systems. These steels are lower in cost than high-performance nickel alloys, are weldable, and possess good high-temperature creep strength (resistance to time dependent elongation) to go along with superior high-temperature corrosion resistance. The compositions of the alloys uniquely balance good high-temperature corrosion behavior with creep resistance and can be cast into near-net shape products.

## Advantages

- Enable higher temperature operation in harsh environments and, therefore, greater process efficiency and decreased emissions compared with chromia-forming stainless steels
- Preferable to more conventional stainless steels that form chromia surface layers because alumina's slower growth rate and greater thermodynamic stability yields superior high-temperature corrosion resistance in many environments
- Lower cost tube production methods and weldability for use in chemical/petrochemical and power generation applications
- Can be formed into complicated component shapes via casting

## Potential Applications

- A range of energy production, chemical/petrochemical, and process industry applications
- Shaped cast turbine and engine components, tubing, and automotive components
- Any application requiring cast materials with high-temperature corrosion resistance

## Patents

Yukinori Yamamoto, Govindarajan Muralidharan, and Michael P. Brady. *Alumina Forming Iron Base Superalloy*, US Patent Application 13/440,639, filed April 5, 2012.

Govindarajan Muralidharan, Yukinori Yamamoto, and Michael P. Brady. *Cast Alumina Forming Austenitic Stainless Steels*, US Patent 8,431,072 B2, issued April 30, 2013.

## Inventor Point of Contact

G. Muralidharan  
Materials Science and Technology Division  
Oak Ridge National Laboratory

## Licensing Contact

Alexander G. DeTrana  
Senior Technology Commercialization  
Manager  
Technology Commercialization  
UT-Battelle, LLC  
Oak Ridge National Laboratory  
Office Phone: 865.576.9682  
E-mail: detranaag@ornl.gov