Improved Martensitic Steel for High Temperature Applications

Opportunity

Research is active on the patented technology, titled "Heat-Treated 9 Cr-1 Mo Steel for High Temperature Application." This technology is available for licensing and/or further collaborative research from the U.S. Department of Energy's National Energy Technology Laboratory (NETL).

Overview

The operating efficiency of coal-fired power plants is directly related to combustion system temperature and pressure. Incorporation of ultra-supercritical (USC) steam conditions into new or existing power plants can achieve increased efficiency and reduce coal consumption, while reducing carbon dioxide emissions as well as other pollutants. Traditionally used materials do not possess the optimal characteristics for operation under USC conditions. Advanced stainless steel alloys and fabrication processes are needed for operation under such extreme conditions. Development of USC boilers and turbines will require materials with high-temperature creep strength, oxidation resistance, corrosion resistance, thermal fatigue resistance, and deformation resistance. Martensitic grades of stainless steel which contain chromium (Cr) and carbon offer an alternative for high temperature applications due to their corrosive resistance and ability to be hardened by heat treatment. Further, these alloys offer a potentially more cost-effective solution when compared to nickel-based superalloys.

NETL has developed a stainless steel composition and heat treatment process for a high-temperature, titanium alloyed 9 Cr-1 molybdenum alloy exhibiting improved creep strength and oxidation resistance at temperatures up to 650 °C. The novel combination of composition and heat treatment produces a heat-treated material containing both large primary titanium carbides and small secondary titanium carbides. The primary titanium carbides contribute to creep strength while the secondary titanium carbides act to maintain a higher level of Cr in the finished steel for increased oxidation resistance, and strengthen the steel by impeding the movement of dislocations through the crystal structure. The heat-treated material provides improved performance at comparable cost to commonly used high-temperature steels and requires heat treatment consisting solely of austenization, rapid cooling, tempering, and final cooling, avoiding the need for any hot-working in the austenite temperature range.

Significance

- Improved high temperature operating characteristics including increased creep strength and oxidation resistance under USC steam conditions
- Comparable cost to commonly used high-temperature stainless steels
- Heat treatment process does not require hot-working in the austenite temperature range

Applications

- Advanced high-temperature power plant componentry including coal-fired boilers, steam and gas turbines, tubing, and piping
- Other applications where heat- and oxidative-resistant stainless steel components are required

Patent Details

U.S. patent number 8,246,767 issued August 21, 2012

U.S. patent number 8,317,944 issued November 27, 2012

Inventors: Paul Jablonski, David Alman, Omer Dogan, Gordon Holcomb, and Christopher Cowen

Contact

NETL Technology Transfer Group
techtransfer@netl.doe.gov

September 2012