# Method to Improve Steel Creep Strength by Alloy Design and Heat Treatment

## Opportunity

Research is active on the patent pending technology, titled "Creep Resistant High Temperature Martensitic Steel." This technology is available for licensing and/or further collaborative research from the U.S. Department of Energy's National Energy Technology Laboratory.

## Overview

The operating efficiency of coal-fired power plants is directly related to combustion system temperature and pressure. Incorporation of ultrasupercritical (USC) steam conditions into new or existing power plants can increase efficiency and reduce coal utilization, while reducing carbon dioxide emissions. Traditional materials used in USC power plants do not possess the creep capability for long-term use above 610 °C. Under USC conditions, the 9% chromium (Cr) martensitic steels exhibit shortened component functional lifespan or require the use of thicker components or the substitution of more costly austenitic stainless steels or nickel-base alloys, resulting in increased costs. As a consequence, advanced steels and manufacturing processes are needed to develop materials for use in these extreme conditions.

The current invention describes a steel formulation and manufacturing approach that produces USC creep capable, high Cr martensitic steel for advanced fossil power generation. The creep-resistant steel is based on a combined strategy of strengthening the matrix with solute additions and ultra-fine precipitates, stabilizing the grain and sub-grain structure using carbides, and creating a high density of dislocations through the martensitic phase transformation using traditional thermo-mechanical processing and heat treatment. Aside from the careful control of minor elements, another unique feature of this integrated approach to high-temperature materials development lies in the computationally-based homogenization step that uniformly distributes hard to diffuse elements such as Cr, cobalt, and molybdenum within the martensitic matrix, thereby facilitating microstructure and phase stability at high temperatures.

The approach builds upon existing alloy design fundamentals but makes use of computational materials design strategies both in the selection of steel target chemistries suitable for high temperature creep strength and heat treatment, as well as the homogenization heat treatment schedule to insure uniformity of elements within the matrix. The resulting steel is similar to existing steels in terms of general microstructure features, but to date has shown creep capability twice that of existing commercial 9% Cr martensitic steels.

## Significance

- Excellent and consistently achievable tensile mechanical properties
- Improved creep resistance under high temperature USC steam conditions
- Increased creep strength does not impact steel fabrication processing
- Extended functional lifespan of boiler and steam turbine components

## Applications

- Advanced high-temperature steam components including rotors, airfoils, casing, valves, and other ancillary components
- Material substitution for P/T91 and P/T92 steels in coal-fired boilers
- Other high-temperature applications where creep-resistant martensitic steel is required

## Patent Details

U.S. Non-provisional Patent Application No. 13/868,139 was filed April 23, 2013, titled "Creep Resistant High Temperature Martensitic Steel."

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