Available for Licensing

METHOD TO IMPROVE STEEL CREEP STRENGTH BY ALLOY DESIGN AND HEAT TREATMENT

OPPORTUNITY:

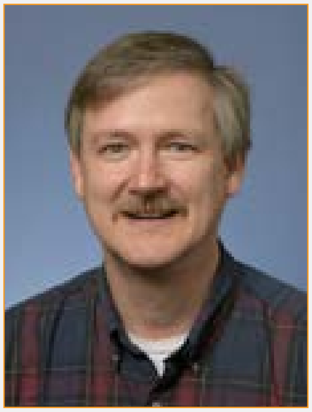
Research is active on the development and refinement of metallurgical processes for improving alloy performance under extreme operating conditions found in fossil energy power plants. These inventions are available for licensing and/or further collaborative research from the U.S. Department of Energy's National Energy Technology Laboratory.

OVERVIEW:

The operating efficiency of coal-fired power plants is directly related to combustion system temperature and pressure. Incorporating advanced ultrasupercritical (AUSC) steam conditions into new or existing power plants can increase power plant efficiency while reducing coal use, and by implication reducing carbon dioxide emissions. Under AUSC conditions, system components like boilers and turbines are exposed to a variety of extremely high temperatures and pressures—aggressive oxidizing and reducing environments in the boiler and oxidizing conditions in the turbine, that either shorten component lifespan or require the use of thicker components or more costly alloys, resulting in increased cost with little or no improvement in cycle efficiency. Conventional commercial materials do not possess the optimal characteristics for operation under the more stringent AUSC conditions. Therefore, advanced, higher temperature capable steels and novel manufacturing processes are needed to develop these alloys as well as other metallic heat resistant materials for use in these extreme conditions.

Jeffrey Hawk

This invention describes a steel formulation and manufacturing approach that produces AUSC creep capable, high chromium (Cr) martensitic steel for advanced fossil power generation. The creep resistant steel is based on a combined strategy



Paul Jablonski

(continued)

of strengthening the matrix at all length scales with solute additions and ultra-fine precipitates, stabilizing the prior austenite grain structure as well as the 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.

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 a novel homogenization heat treatment step to insure uniformity of elements within the matrix. The resulting steel is similar to existing commercial steels in terms of general microstructure features, but to date has shown creep capability of at least twice that of existing 9 percent Cr martensitic steels. In addition, steels produced using this method demonstrate improved oxidative resistance and exhibit more consistent, and superior, mechanical properties at temperatures up to 650 °C. Alloys developed using this method are expected to significantly extend the functional lifespan of selected components in advanced high-temperature power plants, including coal-fired boilers, steam and gas turbines, and piping, as well as other applications where heat- and oxidative-resistant martensitic steel components are used. Performance of the alloy has been demonstrated at a process scale that directly translates to industrial practice, making the new technology attractive for near-term commercialization.

SIGNIFICANCE:

- Excellent and consistently achievable tensile mechanical properties
- Improved creep resistance under high temperature AUSC steam conditions
- Increased creep strength does not impact steel fabrication processing
- Extended functional lifespan of boiler and steam turbine components
- Applicable to both wrought/forged products as well as thick-wall castings

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 high strength, creep-resistant martensitic steel is required

RELATED PATENTS

- U.S. Patent No. **9,181,597** issued November 10, 2015, titled "Creep Resistant High Temperature Martensitic Steel." Inventors: Jeffrey Hawk, Paul Jablonski, and Christopher Cowen
- U.S. Patent No. **9,556,503** issued January 31, 2017, also titled "Creep Resistant High Temperature Martensitic Steel." Inventors: Jeffrey Hawk, Paul Jablonski, and Christopher Cowen

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