the ENERGY lab

PROJECT FACTS

Advanced Research Materials

Addressing Materials Processing Issues in Components for Advanced Power Generation

Background

Conventional coal-fired power plants utilize steam turbines to generate electricity and operate at less than 40 percent efficiency. Operation at higher temperatures and pressures can lead to greater efficiencies, resulting in reduced fuel consumption and lower greenhouse gas emissions. Advanced systems brought online over the last few years work with supercritical steam—steam above its critical point of pressure and temperature, so that there is no phase transition between water and steam, but only a gradual decrease in density—to achieve up to about 45 percent efficiency.

For the next generation of advanced systems, the Department of Energy (DOE) plans to target advanced ultrasupercritical (AAUSC) steam plant processes that operate at an even higher temperature and pressure to achieve power plant efficiencies approaching 50 percent. Before such plans can be realized, the DOE will need to develop affordable advanced materials capable of operating at AUSC temperatures and pressures in corrosive environments. To this end, the DOE's National Energy Technology Laboratory (NETL) Advanced Research Materials Program has teamed with scientists and engineers in industry and academia to form the AAUSC Steam Boiler Consortium and the AAUSC Steam Turbines Consortium for the purpose of developing advanced materials that are capable of withstanding extreme conditions.

Project Description

This DOE NETL project is intended to identify promising alloys for cast casings for AUSC steam turbines. Turbine casings are massive (up to 10 tons) and are good target components for cost savings by using advanced materials that are also economical, if such materials can be identified. However, traditional casing materials such as ferritic/martensitic steels will not work at 760 degrees Celsius (°C) which is the proposed steam inlet temperature for the AUSC turbine.

At the initiation of this project, researchers identified seven alloys as candidates for use and explored casting versions of seven wrought alloys in order to evaluate their application as casing or valve components for industrial AAUSC steam turbines. These castings were then characterized by evaluating their microstructure and mechanical performance.

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U.S. DEPARTMENT OF ENERGY

PROJECT DURATION

Start Date
10/01/2009

End Date
09/30/2011

COST

Total Project Value
$414,960

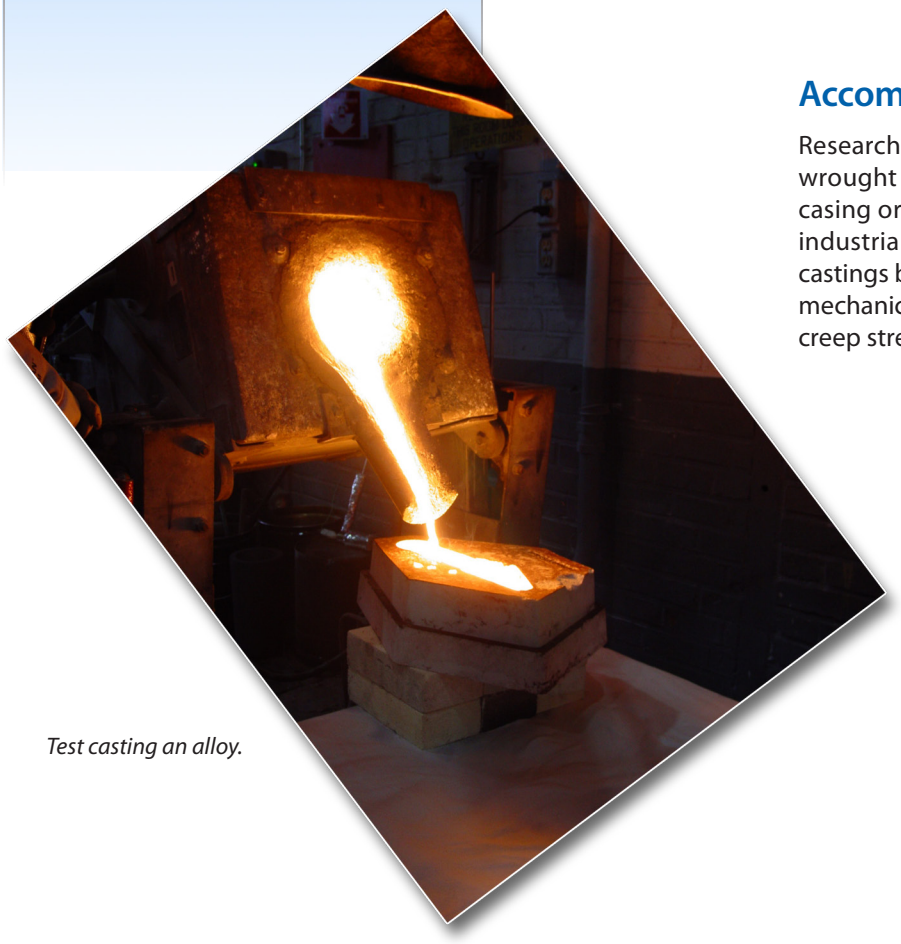
DOE/Non-DOE Share
$414,960 / $0

Researchers will select one-to-three of the seven alloys to further refine for improved castability. This refinement is needed because the target chemistry for any particular wrought alloy is different than the cast version of that alloy. The team will model the selected alloy's chemistry and may also further model the casting process in order to refine cooling profiles which, in turn, will lead to final as-cast microstructures. Researchers will make and evaluate test melts after they model both the alloy chemistry and casting parameters.

As the project progresses, the team will move closer to the production environment, e.g., green sand casting and open chamber casting. Based on these results, modifications will be made to the models, and the models will be used to modify the alloy chemistries for further casting trials. This iterative approach will be employed to identify the appropriate cast alloys and techniques for this application.

Goals and Objectives

The project goal is to contribute to materials development for AAUSC steam turbines. Project objectives include selecting a small number of candidate alloys for cast casings and performing an iterative process of modeling, modifying chemistry, and testing alloys, to achieve a final selection of an appropriate alloy.



Test casting an alloy.

Accomplishments

Researchers have explored casting versions of seven wrought alloys in order to evaluate their application as casing or valve components for the next generation of industrial steam turbines. The team characterized the castings by evaluating their microstructure as well as their mechanical performance in terms of tensile strength and creep strength.

Benefits

Identification of economical alloys suitable for use in AAUSC steam turbines will help to achieve the DOE's targets for increasing production efficiency and reducing unit cost of electricity. These advances in technology will contribute to reduced power plant emissions of greenhouse gases leading to better management of global climate change. In addition, decreased dependence on foreign sources of fuels will improve national energy security.

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