Scientists develop high-performance steel for possible use in ITER fusion project

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Jeremy Busby of the ORNL Materials Science and Technology Division headed development of a new cast stainless steel being evaluated for use in the ITER fusion device.

(PhysOrg.com) -- Researchers at Oak Ridge National Laboratory and the U.S. ITER Project Office, which is housed at ORNL, have developed a new cast stainless steel that is 70 percent stronger than comparable steels and is being evaluated for use in the huge shield modules required by the ITER fusion device.

ITER is a multibillion-dollar international research and development project to demonstrate the scientific and technological feasibility of fusion power and to enable studies of self-heating burning plasmas. It

will require hundreds of tons of complex stainless steel components that must withstand the temperatures associated with being in the proximity of a plasma heated to more than 100 million degrees Celsius.

The ITER device will be assembled in Cadarache, France, using components fabricated in the United States and in the other partner nations – China, the European Union, India, Japan, the Republic of Korea and the Russian Federation. It is based on the tokamak concept, in which a hot gas is confined in a torus-shaped vessel using a magnetic field. When operational, the device will produce some 500 MW of fusion power.

Jeremy Busby of the ORNL Materials Science and Technology Division said the ITER shield modules present a particular challenge. "The United States must produce nearly 100 of these modules that are 3-4 tons each and include geometric shapes and openings," he explained, adding that drilling holes in solid steel would result in the removal and loss of 30 percent of the material.

Busby said casting the steel into a near-final shape was another alternative, but it weakens its properties. "We're working to improve the materials' properties to reduce the amount of machining and welding and allow for better performance," he said. "The use of casting can have potential value engineering benefits resulting in cost savings on the order of 20 to 40 percent as compared to machining, so this could be a fairly significant economic issue, both for ITER and in other future uses."

Busby and his team have worked on the effort for some 18 months, after being approached by Mike Hechler, USIPO manager of Blanket Shielding and Port Limiter systems. "He talked with us because of ORNL's materials science expertise," Busby said. "He was familiar with our industry work and hopeful that we could help provide a solution."

The team has utilized a science-based approach involving modeling, advanced analytical techniques and industrial experience, building upon past R&D 100 award-winning efforts with other cast steels. The availability of advanced materials property simulations at ORNL also played a significant role. "We have used all the science tools available to us at the laboratory," Busby added.

The effort began with the preparation of test steel compositions in small batches that will be scaled up to more representative geometries. Focus areas include improvements in fracture properties, tensile strength, microstructure properties, welds, impact properties, corrosion performance and radiation resistance.

Busby is hopeful about when the new material might be needed for ITER. The overall design of the device is being tweaked as part of an international review held earlier this year. "We expect to hear fairly soon about how our cast stainless steel may be used in this groundbreaking project," he said.

Provided by Oak Ridge National Laboratory