New alloy verified for safer disposal of spent nuclear energy fuel

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A new alloy developed and patented by researchers at Lehigh University, Sandia National Laboratory and Idaho National Laboratory could help the U.S. dispose more safely of 50,000 tons of spent nuclear energy fuel that are now stored at 125 sites in 39 states.

John DuPont, professor of materials science and engineering at Lehigh and principal investigator on the project, said that a nickel-based alloy with added gadolinium showed far greater ability than any other alloy to absorb the deadly radioactive neutrons emitted by nuclear waste.

The researchers found that the gadolinium-nickel alloy passed an important test - it can be fabricated in large quantities using conventional ingot metallurgy and fusion welding techniques.

The researchers' discovery, which was announced in an article in the December 2004 issue of the American Welding Society's Welding Journal, caps a four-year study funded by the U.S. Department of Energy's (DOE) Spent Nuclear Fuel Program.

The article, titled "Physical and Welding Metallurgy of Gadolinium-enriched Austenitic Alloys for Spent Nuclear Fuel Applications - Part II," won the society's Warren F. Savage Award for advancing the understanding of welding metallurgy.

The article comes amidst a controversy over plans by the Bush Administration and Congress to transport the nation's spent nuclear fuel to Nevada and deposit it inside Yucca Mountain about 90 miles northwest of Las Vegas.

In 2002, over the objections of Nevada Governor Kenny Guinn, Congress passed, and President Bush signed into law a resolution approving Yucca Mountain as the storage site for the nation's spent nuclear fuel.

DOE's application for a license to build the project is pending before the federal Nuclear Regulatory Commission. The state of Nevada, contending that the Yucca Mountain project is environmentally and geologically unsafe, has filed lawsuits against DOE, NRC, Bush and former DOE Secretary Spencer Abraham.

Gadolinium, a silvery-white metal. occurs naturally in several different minerals. The collaborative research conducted by Lehigh and the two national labs demonstrated that gadolinium can be added to specific nickel alloys and retain its malleability and ductility, as well as its ability to be heat-treated, shaped and fabricated readily into a desired shape.

More importantly, says DuPont, gadolinium has a neutron-absorption cross- section of 48,800 barn units, more than 60 times greater than the 765-barn cross-section for boron. (Cross-section, the measure of the probability of an interaction between a particle and a target nucleus, is expressed in barn units, with one barn equal to 10-24 cm2.) Borated stainless steel is the material commonly used in conventional nuclear-waste containers. However, borated stainless steel is not capable of housing some of the nations highly radioactive spent fuel.

The higher neutron-absorption capacity of gadolinium, says DuPont, means that highly radioactive fuel can now be safely transported to and stored at a permanent facility.

The research group, which includes DuPont at Lehigh and scientists from Sandia National Laboratories in New Mexico and the Idaho National Laboratory (formerly the Idaho National Engineering and Environmental Laboratory), conducted laboratory tests to determine the optimum amount of gadolinium to add to the nickel-based alloy.

The tests involved mixing the constituent elements of the alloy, heating and melting the mixture, and

allowing it to cool and solidify. The alloy was then heated and rolled into half-inch-thick sheets, and subjected to strength and ductility tests.

"We designed and developed various alloys to determine the quantity of gadolinium that could be added while still maintaining the desired properties," says DuPont. "We needed to be able to heat-treat the final material, weld it and fabricate it."

A specification has been approved for the alloy by ASTM (the American Society of Testing Materials), which sets technical standards for materials, products, systems and services. The alloy is being reviewed by the American Society of Mechanical Engineers, which also sets standards for the use of new products. Neutronics (neutron-absorption) tests on the alloy were performed at Lawrence Livermore National Laboratory in California.

The research team was awarded a U.S. patent for the alloy last year.

Prior to its work with the gadolinium-nickel alloy, the researchers spent a year investigating gadolinium-enriched stainless-steel alloys for spent nuclear fuel storage applications before coming up against major obstacles to the production of those alloys using conventional hot working techniques.

Source: Lehigh University