Development of Gadolinium-Alloyed Nickel Based Materials for Spent Nuclear Fuel Storage and Disposal

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Introduction

Gadolinium (Gd) is a potent neutron absorber that can provide nuclear criticality control for storage, transport, and disposal of spent nuclear fuel. This material property makes Gd an ideal alloying element for parts that provide structural support, corrosion resistance, and criticality control. The development of a technique by which Gd could be incorporated into an alloy that can be easily fabricated into these shapes becomes essential for this spent fuel storage and disposal applications.

Experimental Procedure

Alloying of Gd into Ni-based alloys has been identified as a potential approach to these requirements, but no information is available that describes the solidification, Weldability, or microstructure of such alloys. Alloy plates, based on conventional Ni alloy compositions and containing approximately 2 wt% Gd, were produced by conventional ingot metallurgy and hot working. The influence of Gd on the solidification and Weldability of these alloys has been evaluated through microstructural analyses, differential thermal analysis, hot ductility testing, Varestraint testing, and mechanical property assessments.

Results and Discussion

Solidification initiates with the formation Ni austenite and terminates by the formation of a eutectic-like constituent consisting of austenite and a phase based on the $GdNi_5$ intermetallic compound. The solidification temperature range is on the order of 150°C. Hot ductility measurements indicate that the elevated temperature ductility is generally adequate for rolling of plate, and is commensurate with other alloys with appreciable secondary constituent levels. Autogenous electron beam and gas-tungsten arc welds and Varestraint testing indicate that hot cracking resistance and fabrication Weldability are generally acceptable for large-scale fabrication. Mechanical properties for base metal, autogenous, and filler metal welds will be reported, compared with Gd-free alloys, and discussed in terms of the microstructure. The results imply that primary and secondary processing of these unique alloys is feasible, and merits further development.

Conclusion

The effects of Gd on the solidification behavior and Weldability of Gd-bearing nickel-based alloys have been determined. Nickel-base alloys containing 2% Gd solidify primarily as austenite and terminate with the formation of eutectic-like constituent of austenite and $GdNi_5$. Weldability and hot ductility teting indicate that these materials are generally acceptable for large-scale fabrication.

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