Task 10

Development of a Mechanistic Understanding of High-Temperature Deformation of Alloy EP-823

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GOAL AND BACKGROUND

Alloy EP-823 has been developed as a structural material for Lead Bismuth Eutectic (LBE) systems, such as those under development for nuclear transmutation systems, as well as other applications. However, very little data regarding the mechanical properties of this alloy exists in the open literature, particularly in the temperature regime of interest for transmutation systems. To address this need, the UNLV research team, in collaboration with researchers from Los Alamos National Laboratory, has developed a research program to evaluate tensile properties of Alloy EP-823 stainless steel at elevated temperatures, which is not being performed at any other facility to date. Overall, results will lead to the development of a mechanistic understanding of the elevated-temperature deformation processes in this alloy as a function of thermal treatment.

RESEARCH OBJECTIVES AND METHODS

The focus of this work is to evaluate the effect of elevated temperatures (300-540 C) on the tensile properties of the candidate target material, Alloy EP-823. The impact of heat treatment on the tensile properties will also be evaluated. Test materials will be heat treated and machined prior to the measurement of their tensile properties at temperatures relevant to the transmutation applications.

Graduate student Martin Lewis will be trained on the mechanical testing equipment and surface analysis techniques. Deformation characteristics of tensile specimens will be evaluated by surface analytical techniques using scanning electron microscopy (SEM) and transmission electron microscopy (TEM). Metallurgical microstructures of the broken tensile specimens will be evaluated using standard methods such as polishing and etching. The morphology and extent of failure in each specimen tested will be studied using the SEM. TEM will be used to study high-temperature deformation characteristics including the distribution and nature of dislocations and other imperfections that will establish deformation mechanisms for the tested material.

Effect of temperature on mechanical properties will be determined and correlated with changes in microstructure for the different heat treatments. This work will serve as part of the work scope for the M.S. Thesis of Martin Lewis. The proposed research program will also generate the following data:

- Uniform elongation vs. temperature;
- Reduction in area vs. temperature;
- Yield strength vs. temperature;
- Ultimate tensile strength vs. temperature;
- Metallurgical microstructure vs. thermal treatment;
- Failure mode (ductile vs. brittle) vs. thermal treatment; and,
- Deformation modes (TEM).

Tensile testing machine with elevated temperature jacket.

RESEARCH ACCOMPLISHMENTS

Three batches of EP-823 alloy have been melted. Ingots processed by hot working converted them into round bars at an off-site facility. One batch of this material has been heat treated (quenched and tempered) at UNLV to produce a fully tempered martensitic microstructure. The hardness of the material has been measured, and experiments are well underway to machine tensile specimens from these heat treated bars.

Ambient-temperature tensile data will be generated as the test specimens become available. To allow tensile testing in the inert gas chamber, round wedges for specimen grips in the MTS were ordered. Currently, these round bars are being evaluated using MTS equipment to generate ambient temperature mechanical properties. The high-temperature, inert gas chamber for the high-temperature mechanical testing has arrived and has been installed. Service connections (water, 220V power, and gas lines) are currently being installed in the laboratory and connected to this experimental system.

Testing specimens.

Martin Lewis, a M.S. graduate student in the Mechanical Engineering Department presented a paper at the ANS student mini-conference in Reno, NV. "High Temperature Deformation Characteristics of Alloy EP-823" highlighted work completed on this martensitic stainless-steel from initiation of this project until November 2001.

Heavy duty torsion and tensile testing machine.

FUTURE WORK AND GOALS

The high temperature experiments on EP-823 will be initiated once the service connections for the laboratory are installed. The experimental campaign will then continue with the remaining alloy batches and the impact of heat treatments will be examined.

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