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Use of Positron Annihilation Spectroscopy for Stress-Strain Measurements: Quarterly Progress Report (June 01 – August 31, 2003)

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Use of Positron Annihilation Spectroscopy for Stress-Strain Measurements

TRP Task-14

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Introduction

The purpose of this collaborative research project involving the University of Nevada Las Vegas (UNLV), the Idaho State University (ISU), and the Los Alamos National Laboratory (LANL) is to evaluate the feasibility of determining residual stresses in cold-worked, plastically-deformed (bent), and welded materials using a nondestructive method based on positron annihilation spectroscopy (PAS). This technique uses γ-rays from a small MeV electron Linac to generate positrons inside the sample via pair production. This method is known to have capabilities of characterizing defects in thick specimens that could not be accomplished by conventional positron technique or other nondestructive methods. The generated data will be compared to those obtained by other methods such as neutron diffraction and X-ray diffraction (for thin specimens), and ring-core (destructive-for thick specimens) methods. During the initial phase, residual stresses induced in experimental heats of austenitic Type 304L stainless steel, and martensitic Alloy EP-823 have been determined by X-ray diffraction (XRD), PAS and ring-core techniques. More recently, efforts are ongoing to include Alloy HT-9, another martensitic stainless steel to perform similar measurements on this alloy using all four techniques. Later, irradiated materials may be evaluated. Low-level radiation will be induced in the test specimens at the ISU, followed by residual stress measurements using the PAS method.

Personnel

The current project participants are listed below.

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Accomplishments:

- A Linear Accelerator (Linac) of higher frequency was used to measure residual stresses using the PAS technique to perform the measurements more precisely. Measurements were performed on the cold-worked and the welded specimens of Type 304L Stainless Steel (SS) and Alloy EP-823.
- A research proposal was submitted to the Atomic Energy of Canada Ltd (AECL) to perform residual stress measurements on different configurations of test specimens using the neutron diffraction technique.
- Identified a different research facility (Oakland University in Michigan) to perform ring-core measurements on test specimens of different configurations. A quotation was also received on the cost estimate associated with these measurements.
- A vacuum-induction-melt of Alloy HT-9 was prepared at the Timken Company for fabricating different kinds of test specimens for future residual stress measurements.
- A technical paper was orally presented at the ANS conference in San Diego, CA.
- A several papers were also sent to numerous conferences for presentation and publications.

Problems:

The Linacs at the Idaho Accelerator Center (IAC) of the Idaho State University (ISU) have been malfunctioning. This has delayed measurements by the PAS technique. However, this problem is currently being rectified. The testing will resume as the Linacs become functional. Due to the unanticipated delay in residual stress measurements at LANL by neutron diffraction, significant efforts were made to accomplish this goal by developing a collaborative research program with AECL.

Status of Funds

Expenditures incurred during this quarter are within the target amount allocated.

Plans for the next quarter:

- Development of calibration curves by the PAS technique on different alloys by using unstressed, and stressed (different magnitudes) tensile specimens (S/T parameter vs applied stress/strain).
- Residual stress measurements by neutron diffraction method at AECL.
- Residual stress measurements by ring-core method at Oakland University.
- Use of Transmission Electron Microscope (TEM) to analyze voids and dislocations due to plastic deformation/welding.
- Standardization of the PAS technique for residual stress evaluation in specimens of different configurations.