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Use of Positron Annihilation Spectroscopy for Stress-Strain Measurements: Quarterly Progress Report (June 01 – August 31, 2004)

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Quarterly Progress Report
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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 data generated by the PAS method has been compared to those obtained by other methods such as neutron diffraction (ND) and the X-ray diffraction (for thin specimens), and ring-core (destructive-for thick specimens) techniques. During the initial phase of this task 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 (RC) techniques. More recently, residual stress measurements have been performed on Alloy HT-9 using all four techniques. . Future testing will be focused on the evaluation of residual stresses in irradiated materials, and welded specimens, with and without post-weld-thermal-treatment (PWTT). Transmission electron microscopic analyses will also be performed.

Personnel

The current project participants are listed below.

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Accomplishments:

Three students recently completed their M.S., degree in Mechanical Engineering specializing in areas of residual stress measurements by both destructive and nondestructive techniques. The particulars are given below.

Student	M.S. Thesis Topic	Graduation Date
Satish Babu Dronavalli	Residual Stress Measurements and Analyses By Destructive and Non-destructive Techniques	July 15, 2004
Vikram Marthandam	Metallurgical Characterization and Residual Stress Measurements of Target Structural Materials	July 20, 2004
Anand Venkatesh	Comparative Analyses of Residual Stresses In Target Subsystem Materials	July 22, 2004

Highlights of Test Results:

- Residual stress measurements by the RC method on cold-worked specimens showed tensile residual stresses in austenitic stainless steel. However, compressive residual stresses were observed in martensitic stainless steel. This difference may be attributed to the difference in metallurgical phases and microstructures resulting from different thermal treatments imparted to them.
- Residual stress measurements by both ND and RC techniques on welded specimens showed similar patterns. Welded specimens consisting of similar material showed tensile residual stresses in the vicinity of the fusion line (FL). However, welded specimens consisting of dissimilar materials (austenitic and martensitic stainless steel on opposite side) showed a different pattern, in that residual stresses were compressive near the FL on the martensitic stainless steel side as opposed to tensile residual stresses on austenitic stainless steel side of the same specimen.
- The measurements of residual stresses by the PAS technique revealed a reduction in T-parameter with the increased plastic deformation for both austenitic and martensitic stainless steels. A reduced T-parameter indicates enhanced residual stresses in either Alloy.

Other Accomplishments:

- One graduate student performed PAS measurements on welded specimens consisting of both similar and dissimilar materials at Idaho State University (ISU) during the summer of 2004. .Also, tensile test specimens were subjected to the activation process using ISU accelerator to develop calibration curves. Data analyses are ongoing.
- Several papers, based on recent data, were presented in technical society meetings. Some of these papers are currently under review for publication in technical journals.

- Significant progress has been made to characterize residual stresses in terms of dislocation density by using TEM.

Problem:

The recent PAS data obtained at ISU need to be analyzed using a software program developed by researchers at ISU. Some delay is anticipated in this regard.

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 for different alloys by using unstressed, and stressed (different magnitudes) tensile specimens (S/T parameter vs. applied stress/strain).
- Comparison of residual stresses using calibration curves developed on activated and inactivated test specimens.
- Performance of additional residual stress measurements by ND method at AECL.
- Evaluation of the role of PWTT on the residual stresses in welded specimens.
- Use of 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.