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INVESTIGATING THE MICROSTRUCTURAL HOMOGENEITY AND DEFORMATION BEHAVIOR OF STEEL STANDARD SPECIMEN

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INTRODUCTION

Steel is an integral alloy used in many applications due to its superior properties that makes it the best choice. The fields where Steel can be used are enormous ranging from the production of sealed radioactive source capsules in research reactors up to the huge reactor vessel in a nuclear power plant. Such wide range of applications makes non-destructive testing (NDT) a fundamental part of the life-cycle of a nuclear industry. It supports, the purpose of investigating and identifying any discontinuities that might or might not be present. Discontinuities are of various types, including cracks, pores or any non-homogeneity that might have an effect on the performance of the test object while in service 1. NDT would be the ultimate tool for monitoring such discontinuities and understanding the mechanisms which affect the mechanical properties of the component in order to be able to stay updated with the current status of the test object, in addition to the prediction of the expected lifetime for it too 2.

EXPERIMENTAL PROCEDURE

Scanning contact potentiometry (SCP) is a new non-destructive testing method that provides the opportunity to assess the internal structure of a test object's material without causing any damage. SCP technique opens up the opportunity for real-time NDT of surface stress and strain, plastic deformation mechanisms, stages of development of internal flaws up to the point of material failure 3,4.

In the Material Testing Laboratory, at Jordan Atomic Energy Commission, experiments were conducted under ambient conditions using standard reference specimen made up of steel. In order to perform the SCP test, a semi-automated scanner device, was designed and manufactured. Measured data is automatically recorded and saved to a special measuring information system (MIS). SCP was performed before and after a tensile test was conducted on a steel specimen. The uni-axial tensile test was performed using the universal testing machine H50KS existed in the laboratory 5. In order to study the early stages of deformation, the tensile test was terminated when the specimen exceeded the elastic region and entered the plastic one, where the values of both stress and strain were (σ_max=354.5 MPa ,ε_max=5.2 %), respectively. The test using the SCP was conducted at a scanning speed of 0.3 mm/s along the surface of the specimen using 6 tracks which covered most of the surface area of the gauge.

RESULTS

Results obtained from the, SCP, performed on the steel standard reference material specimens, were represented using potentiograms 6. The potentiograms obtained show clearly the moment of formation of micro-deformations within the internal structure of the specimen, due to the tensile strain it is exposed to, causing the detection of a structural level signal (SLS ≈5) which is equivalent to 10 μV.

The moment at which micro-deformations appeared was further proved by the results obtained from full width at half maximum (FWHM) of distribution histograms at (SLS≈5) before and after the tensile test was conducted. The values obtained from the FWHM distribution histograms of contact potential differences, measured at the surface, were found to be lower after the tensile test. Furthermore, it was observed that new micro-deformations peaks appeared in the histograms after the tensile test have been performed, which were not present before the test, confirming the efficiency of this method in detecting materials' deformation.

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