Name KRISTEL VAN OUYTSEL
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Abstract

The PhD thesis comprises a literature survey, a chapter on the construction of the torsion pendulum and a results & discussion chapter.

Forming part of the literature survey, the non-destructive internal friction (IF) technique finds its place within a structure building the elastic-to-plastic region founded on dislocation theory. This provides the environment in which IF can prove its aptitude to provide a microstructural basis for damage modelling within the frame of enhanced commercial surveillance of nuclear reactor power plants in Belgium.

A summary of a literature survey on the influence of the chemical composition and various point and dislocation-type defects on the effect of neutron irradiation and thermal treatment is given.

The literature survey ends with a description of the relaxation phenomena in iron and steel of interest in this field of research.

Next, the construction details of a new inverted torsion pendulum designed to investigate pressure-vessel steels at high strain amplitudes (10^{-4}-10^{-2}) over a wide temperature range, 90-700K, at approximately 1 Hz in the irradiated condition are related.

The results of the measurements by means of the torsion penduli at the EPFL (Ecole Polytechnique Fédérale de Lausanne) in Switzerland and the SCK•CEN (Belgian Nuclear Research Centre Mol) in Belgium are subsequently discussed.

The measurements were carried out on a variety of reactor pressure vessel (RPV) steels: A533B Class 1 (JRQ), Belgian RPV steels: Doel-I-II and Doel-IV, an SA508 Class 3 steel, German 22Ni-Cr-Mo37, MnNiMoV and 20Mn-Mo-Ni55 steels and an American HSSI (73W) steel, and provide support for the applicability of the research described herein to commercial surveillance of pressure vessels.

Temperature-dependent (TD) and amplitude-dependent (AD) internal friction experiments have been carried out, the former providing evidence of the existence of the Snoek and Snoek-Köster mechanisms and proposing the combined influence of seven dislocation-related relaxations in these steels and the latter providing a non-destructive means to determine the yield stress.

- a nitrogen Snoek peak was detected in a Si-killed C-Mn steel from which we conclude that the influence of strain ageing can be investigated in these RPV steels by means of the new torsion pendulum.
- a model involving seven dislocation-type relaxations has been introduced to explain the post-deformation IF behaviour. Effects of neutron irradiation (at 290°C), thermal ageing (at 300°C) and post-irradiation annealing are explained.
- the Snoek-Köster process is found to exist in these pressure-vessel steels and has contributed to a more profound understanding of effects of thermal ageing on both TDIF and ADIF.
- from the ADIF investigations, a transition region was determined furnishing a critical strain amplitude which is related to the yield stress of the material; the results for the materials in the unirradiated, thermally aged, irradiated and post-irradiation-annealed condition compare excellently with static tensile data and with a two- or three-component model for the yield stress.

The TDIF results support and provide an explanation for the ADIF results.

Internal friction is shown to represent a strong non-destructive microstructural investigation technique worthy of its introduction into future commercial surveillance programmes of nuclear reactor pressure vessels with the potential of truly understanding on a qualitative and quantitative basis the influence on embrittlement of dislocation