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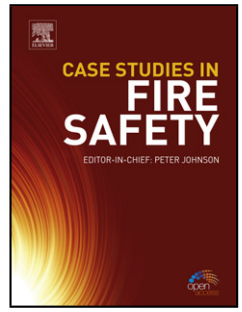

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Stress determination by *in situ* X-ray diffraction - Influence of water vapour on the Zircaloy-4 oxidation at high temperature

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Highlights

- *In situ* growth stress determination in the oxide scale has shown that the compressive stress is larger in dry air compared to the wet air environment at 500 °C. In wet air, the lower growth stress is due to stress relaxation after the pre-transition stage. This is related to the effect of water vapour on the zirconia chemical state and change in the oxide mechanical properties leading to an earlier scale cracking.

ABSTRACT

A key parameter for the understanding the effect of water vapour on the oxidation mechanism is the determination of the stress level in the zirconia scale formed on Zircaloy-4 (Zy-4) at the operating temperature. In order to provide an accurate description of the structure and microstructure of the oxide layers, X-ray diffraction (XRD) analyses have been performed *in situ* under dry and wet oxidizing environments at high temperature on Zy-4 flat sheet samples. The aim of the present work is to show the influence of water vapour on the stress developed at high temperature in the oxide scale as well as inside the alloy. *In situ* growth stress determination in the oxide scale has shown that the compressive stress is larger in dry air compared to the wet air environment at 500 °C. In wet air, the lower growth stress is due to stress relaxation after the pre-transition stage. This is related to the effect of water vapour on the zirconia chemical state and change in the oxide mechanical properties leading to an earlier scale cracking.

Keywords: Water Vapour, Zircaloy-4, Stress determination, *in situ* X-ray diffraction (XRD).

1. Introduction

Increased attention has been paid to the vulnerability of the Spent Fuel Pools (SFPs) since the Fukushima accident. This vulnerability is of major concern for nuclear safety because SFPs which are large water-filled structures are generally placed outside the reactor containment building so that the fuel clad is the only barrier against fission product release in case of dewatering. In the case of a loss of primary coolant accident in a light water reactor, the zirconium alloys fuel cladding would be oxidized in air and steam at high temperature. To gain