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Effect of temperature and dissolved oxygen on stress corrosion cracking behavior of P92 ferritic-martensitic steel in supercritical water environment

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Abstract: The effect of temperature and dissolved oxygen (DO) on stress corrosion cracking (SCC) of P92 martensitic steel in supercritical water (SCW) was investigated using slow strain rate test (SSRT) and fractography analysis. The SSRT was carried out at temperatures of 400, 500, 600 ^{o}C in deaerated supercritical water and at DO contents of 0, 200, 500 ppb at the temperature of 600 ^{o}C, respectively. The results of SSRT show that the decrease of ductility at the temperature of 400 ^{o}C may be related to the dynamic strain aging (DSA) of P92 steel. The degradation of the mechanical properties in SCW is the joint effect of temperature and SCC. Compared with the effect of temperature, DO in SCW has no significant effect on the SCC susceptibility of P92 steel. The observation of oxide layer shows that large numbers of pores are nucleated in the oxide layer, which is related to vacancy accumulation and hydrogen generated in the oxide layer. Under the combined action of the growth stress and tensile stress, micro cracks, nucleated from the pores in the oxide layer, are easily propagated intergranularly outward to the surface of specimen, and fewer cracks can extend inward along the intrinsic pores to the inner oxide/metal interface, which is the reason for the exfoliation of oxide films.

Key words: ferritic-martensitic (F/M) steel; supercritical water (SCW); temperature; dissolved oxygen; stress corrosion cracking

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1. Introduction

The supercritical water-cooled reactor (SCWR) under the Generation IV program is a promising advanced nuclear systems due to their high thermal efficiency (i.e., about 45 % vs. 33 % efficiency for current Light Water Reactors LWRs), optimization and simplification design. SCWRs are operating at higher pressure and temperatures than LWRs with a direct once-through cycle to increase the fuel efficiency [1-3]. In the SCWRs, the operating temperature is expected to be in the range 500~550 ^{o}C, which is above the thermodynamic critical point (374.2 ^{o}C, 22.1 MPa), and the water in the system exists in the state of supercritical water [4]. Supercritical water, with significantly different corrosion properties as compared to liquid water, is very aggressive for metallic materials