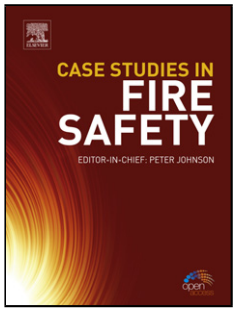

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Development of Heat-resistant Fe-based Alloys for A-USC Steam Boiler using Ultra-high Purity (UHP) Technology

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Abstract

The design of ultra-high purity (UHP) Fe-based alloys for advanced ultra-supercritical (A-USC) technology is suggested in this work. The creep testing at 700°C and a stress level of 150 MPa have been performed in air. The addition of small amount of reactive-elements, W, Nb, Zr and Sc, has been undertaken into model alloys with the intention to promote the precipitation strengthening. Optimizing the chemical composition coupled by pre-straining enabled improving the creep resistance; hence a creep-rupture life of 750 hours was reached. The oxidation resistance in supercritical water is remarkably enhanced by small addition of Sc.

Keywords: Alloy**,** Intermetallics**,** TEM**,** SIMS**,** Oxidation

Introduction

The development trend of novel power plants with high thermal efficiency has been concentrated to advanced ultra-supercritical (A-USC) technology in the last decades. This is essential to achieve the environmental restrictions on CO_2 emissions [1-4]. Coal-fired supercritical power plants are currently operating with steam temperature of 600°C. A-USC technology is aimed at increasing operating temperatures to 700-760°C and main steam pressure to 35 MPa in order to reduce coal consumption and CO_2 emission [5]. To achieve those higher operating parameters, development of materials with excellent properties in terms of creep strength and oxidation resistance is mandatory. The newly developed materials should own acceptable manufacturing characteristics, excellent workability and fabrication cost. Heat-resistant 45Ni-25Fe (wt. %) based-alloy HR6W meets the requirements in A-USC conditions with approximately 900 hours creep-rupture-strength at 700°C and at a stress level of 150 MPa but it has a high cost because of large amount of Ni content [6-8]. It has been reported that the excellent high temperature strength of HR6W is attributed to a fine dispersion of nano-sized particle of Fe_2W Laves-Phase. While a considerable coarsening of $M_{23}C_6$ carbide in this alloy which contain 0.1 wt. % carbon occurred during creep testing [6,9]. The degradation of creep strength can take place by the coarsening of unstable carbides along grain boundaries (GBs) [10-13], since they provide more suitable sites of stress concentration, which in turn promote creep cavities formation and crack initiation [14]. The addition of 23 wt. % of Cr in this