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Evolution of creep behavior of CLAM steel during thermal aging at 550 °C

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Abstract: As the primary candidate structural materials for fusion energy systems, reduced activation ferritic/martensitic (RAFM) steel must to withstand high temperature for a long periods of time. The microstructure of RAFM steel would change due to thermal aging in service, and that would resulting in the change of creep behavior. The aim of this paper is to investigate change of creep behavior of CLAM steel after thermal aging at 550 °C for 2000 h and 4000 h. The results showed that the creep property degenerated obviously after thermal aging. After aging for 4000 h, the creep-rupture time of CLAM sample decreased from 202 h to 111 h and the minimum creep rate increased from 3.61×10^{-4} s^{-1} to 6.84×10^{-4} s^{-1}, compared to un-aged sample. The reason for creep property degeneration was inferred to be that the dissolution of solute atom in CLAM matrix decreased during the process of second phase precipitated and coarsened during thermal aging. The analysis indicated that the maximum operating temperature and rupture life of CLAM sample was decreased by the effect of thermal aging.

Key words: CLAM steel; Thermal aging; Creep deformation behavior;

1. Introduction

The 9-12% Cr martensitic steels such as P91 steel are most popular structure materials used in power plant due to its good mechanical properties at high temperature [1]. In the late of 1980s, a fast induced-radioactivity decay (FIRD) steel was developed for fusion application based on conventional 9% Cr martensitic steels by replacing Nb and Mo with Ta and W, respectively [2-3]. They are commonly known as reduced activation ferrictic/martensitic (RAFM) steels [3]. RAFM steels have been chosen as the candidate structural material for the International Thermonuclear Experimental Reactor Test Blanket Modules (ITER TBM) due to their good irradiation resistance and matured industrial infrastructure, etc. [4-8]. China Low Activation Martensitic (CLAM) steel is one kind of the RAFM steels which have been developed in China [9-11].

As the structural material for TBM in fusion applications, RAFM steels must withstand high temperature during service period. The tempered martensitic microstructures of RAFM steel will evolve and result in degeneration of mechanical