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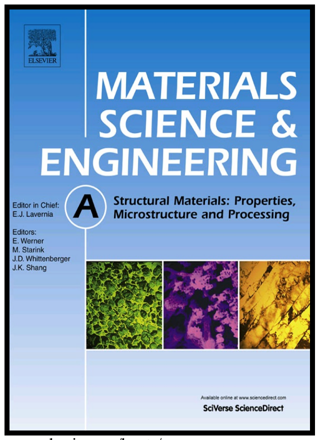

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Abstract
The creep behavior of a 3%Co modified P92-type steel with high content of boron and low content of nitrogen was studied. The precipitation of Laves phase at lath boundaries provides a rapid decrease in the strain rate during transient creep. The finely dispersed (V,Nb)(C,N) carbonitrides uniformly distributed throughout and $M_{23}C_6$ carbides located at various boundaries/subboundaries result in extended steady-state creep. Gradual coarsening and an increase in the volume fraction of $M_{23}C_6$ carbides as well as coarsening of Laves phase particles is accompanied by an increase in the lath size during the steady-state creep. The coarsening of lath structure that is assisted by the dissolution of Laves phase particles at lath boundaries during steady-state creep leads to the onset of tertiary creep with a highly accelerated rate. The well-developed subgrain structure is observed in the ruptured samples, whereas the distance between high-angle boundaries does not change during the creep.

Keywords: Martensite, Steel, Microstructure, Precipitation, Coarsening

1. Introduction

High-chromium martensitic steels are widely used as creep resistant structural materials for various fossil power plant elements, which are exploited at elevated temperatures [1,2]. A P92-type steel alloyed with 0.1%C, 9%Cr, 2%W, 0.5%Mo, 0.2%V, 0.05%Nb is a typical representative of such steels [1-5]. Their alloying composition is designed to provide a long-term creep resistance at high temperatures. Normalizing at 1323K followed by tempering at approx. 1023 K produces the tempered martensite lath structure (TMLS), which is composed of prior austenite grains (PAGs), packets, blocks, and laths with a high dislocation density [1,2,4,6]. The strengthening mechanisms include solid solution strengthening, dispersion strengthening, dislocation strengthening, etc. The solid solution strengthening is provided by such interstitial solutes as carbon and nitrogen and substitutional solutes of W, Mo and Cr. The dispersion strengthening is provided by numerous nanoscale (V,Nb)(C,N) carbonitrides precipitated in ferrite matrix [1-4] and $M_{23}C_6$ carbides located at any boundaries/subboundaries [7-9]. The long-range internal elastic stress fields originated from lath boundaries and lattice dislocations also contribute to superior creep resistance of these steels [6-10].

A degradation of TMLS under creep reduces the creep strength and leads to the creep strength breakdown that strongly diminishes the long-term creep strength [11-17]. The finely dispersed carbonitrides and boundary carbides play a key role in stability of TMLS under creep condition [1-4,8-14]. The $M_{23}C_6$ carbides located at lath boundaries exert a high Zener drag force and play a major role in the stability of TMLS under creep conditions [4,11-14]. The Laves phase particles precipitated during creep at low- and high-angle boundaries may also contribute to the TMLS stability [4,11-14]. The Zener drag force associated with (V,Nb)(C,N) carbonitrides is relatively low [4,11-14]. However, these dispersoids slows down the knitting reaction between the dislocations and lath boundaries. This reaction leads to transformation of the lath boundaries, which