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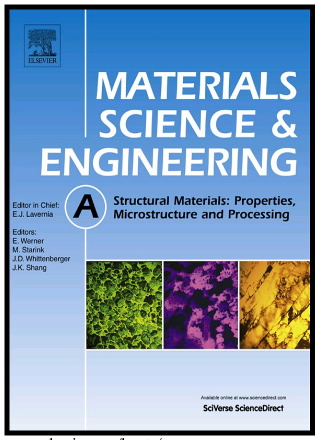

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On the Origin of the Superior Long-Term Creep Resistance of a 10% Cr Steel

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Abstract

A low-nitrogen 10% Cr martensitic steel containing 3% Co and 0.008% B was shown to exhibit an extremely long creep rupture time of ~$4 \cdot 10^4$ h under an applied stress of 120 MPa at 650 °C. The creep behavior and evolution of lath martensite structure and precipitates during creep at these conditions were studied. The main feature of the microstructure under long-term creep is retention of the lath structure until rupture. The following microstructural factors affecting the superior creep resistance were analyzed: 1) alloying by (W+Mo) elements; 2) particles of $M_{23}C_6$ and Laves phases; 3) homogeneously distributed M(C,N) carbonitrides. It was revealed that nanoscale $M_{23}C_6$ carbides and M(C,N) carbonitrides compensated the negative effects of W depletion from the solid solution and extensive coarsening of the Laves phase particles. $M_{23}C_6$ carbides demonstrate a high coarsening resistance under creep conditions and exert a high Zener drag pressure before rupture because of the coherency of their interfaces. The strain-induced transformation of a portion of the precipitated V-rich M(C,N) carbonitrides to the Z-phase does not affect the creep strength because the Z-phase particles are nanoscale and negligible in quantity.

Keywords: martensite; steel; creep; electron microscopy; precipitation; coarsening.

1. Introduction

Creep-resistant martensitic steels with 9–11% Cr are favorable materials for the turbine components of fossil-fuel power plants [1,2]. Their alloying design and heat treatment aim to provide stability to the tempered martensite lath structure (TMLS), which comprises prior austenite