CREEP BEHAVIOR OF LOW-CARBON 9% CR STEEL STRENGTHENED BY TAX NANOPARTICLES

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9-12% Cr martensitic steels are prospective materials for new generation of fossil power plants with steam temperature of 620°C. High creep strength is accompanied with a formation of the tempered martensite lath structure with nigh density of free dislocations. The main structural changes during creep at elevated temperature are considered to be the increase in width of the martensitic laths and decrease in the dislocation density that is accompanied with the growth of $M_{23}C_6$ carbides and Laves phase. The aim of present work is to report on creep behavior of the low-carbon 9% Cr steel in comparison with the 9% Cr steel with 0.1% C. Two steels with the different C content (0.02%C-9% Cr and 0.1%C-9% Cr) were heat treated as normalizing at a temperature of 1200 (for 0.02%C-9% Cr) and 1050°C (0.1%C-9% Cr) during 1 hour, cooling in air, with following tempering at temperature of 750°C during 3 hours, air cooling. Flat specimens with a gauge length of 25 mm and a cross section of 7 mm × 3 mm were crept until rupture at 650 °C under the applied stresses of 120, 140 and 160 MPa. The structural studies were carried out by transmission electron microscopies.

Heat treatment of the steels led to the formation of the tempered martensite lath structure in both steels with different prior austenite grain size: about 200 μm for 0.02%C-9% Cr steel and 20 μm for 0.1%C-9% Cr steel. The size of the martensite laths was about 300 nm in both steels, and the dislocation density was very nigh of $(2\text{-}4)\times10^{14}$ m^{-2}) in both steels. The phase composition of 0.02%C-9% Cr steel includes ferrite and such secondary phase particles as TaX, Laves phase and "Cu"-rich particles, whereas 0.1%C-9% Cr steel contents ferrite, $M_{23}C_6$ carbides, Nb(C,N) and V(C,N) carbonitrides. So, the creep strength of these steels is provided by different type of secondary phase particles. The 0.02%C-9% Cr steel at the applied stress of 160 MPa demonstrates a significant increase in the rupture time by a factor of 3 compared to the 0.1%C-9% Cr steel due to increasing the duration of the primary creep stage by a factor of 3 and decreasing the minimum creep rate by two orders of magnitude. Under 140 MPa, the rupture time is similar for both steel and comprises about 1800 h. Under 120 MPa, the creep specimen of the 0.02%C-9% Cr steel has not been broken yet, but behavior of creep curve is similar with that of the 0.1%C-9% Cr steel. So, the nigh level of threshold stresses from TaX carbonitrides gives the increment in creep strength under the nigh applied stresses, only, whereas $M_{23}C_6$ carbides provide the strengthening effect until their size retains below 100 nm at volume fraction of 2%.

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