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Basic Microstructural Characterization of Second Phases in Homogeneous Weld Joint Made of X6CrNiNbN25-20 Steel After Long-Term Exposure Time at 700 °C

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New blocks of fossil fuel power plants designed for steam temperatures above 600 °C require advanced stainless steels as material for superheater or reheater systems. Weld joints are critical parts in fossil power units. Great attention is paid to the exploitation of new steel grades with higher material properties. In the austenitic steels family, the superior grade is undoubtedly HR3C steel \[X6CrNiNbN25-20]. A detailed knowledge on stability and microstructure composition during thermal exposure of the weld joints made from HR3C is necessary in order to use them in fossil fuel power plants with USC steam parameters.

The aim of the paper is to identify critical minor phases in HR3C steel, which allow acceleration of creep damage. The -phase and rough carbides $M_{23}C_6$ type is considered as such a phases in this steel. In this study, the -phase is identified and studied in more detail in relation to the development of creep damage at 700 °C.

Experimental material of the homogeneous HR3C weld joints in two states: in the as—welded state (AW) and after the post-weld heat treatment (PWHT). Weld joints were manufactured by orbital welding using the GTAW method, heat input Q=1600 J/mm, interpass 150 °C, three beads. Nickel-base alloy UTP A6170 Co (equivalent to Thermanit 617) was used as a filler material. The PWHT was carried out at the temperature of 1230 °C for 15 min. Stress rupture tests were performed on the cross-weld joints of tubes ø 38 x 6.3 mm at 700 °C with times to rupture up to nearly 22,000 hours. The polished surface of the longitudinal sections were subjected to color etching in Murakami (30 g $K_3[Fe(CN)_6]$, 30 g KOH, 60 ml H_2O) in order to highlight the -phase. Several microscopic techniques were used for the study. The results were supplemented by creep, grain size and microhardness data HV 0.5.

The PWHT specimens exhibited a mean -phase size of approximately 5 µm, as well as AW samples. However, time to rupture, such as 20,000 hours, the -phase size for the AW samples was almost twice as large as PWHT. The AW specimens as opposed to the PWHT specimens did not show a noticeable growth of austenitic grains in the heat-affected zone (HAZ). In specimens after PWHT the average grain size in HAZ was more than twice that of the BM. It is worth noting that creep ductility values of specimens in the state after PWHT are very low, which is the result of coarse-grained structure in the HAZ and accelerated precipitation of -phase particles along grain boundaries during creep at 700 °C.

Keywords: HR3C, PWHT, creep-resistant steel, austenitic stainless steel, homogeneous weld joint.

Biography

The author gained a gradual level of education at the Technical University of Ostrava (VSB) in the Czech Republic, EU at the Faculty of Metallurgy and Materials Engineering in the field of Technical Materials. He is currently a postgraduate student at the same faculty with specializing in austenitic creep resisting steels. These steels are used in the construction of thermal power plants in Europe with higher efficiency and therefore with higher steam parameters, which are advanced thermal power plants with A-USC steam parameters. These are steels 25Cr-20Ni based HR3C and 18Cr-8Ni based SUPER304H and TP347HFG with very good creep properties. He participated in research for the project "Research for SUSEN", which will be successfully completed in 2020. The research is a follow-up to the successful European project Sustainable Energy (SUSEN 2020), in which a significant scientific infrastructure in Central Europe was built. He is an investigator of partial projects focused on increasing the efficiency of fossil power plants with activity in the field of transmission electron microscopy (TEM) with high resolution (HR-STEM) scanning mode (STEM) and other modes (EELS) and (XEDS), scanning electron microscopy (SEM), but also conventional microscopy (LM) and special modes (SDCM).