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The influence of hydrogen charging on the notch tensile properties and fracture behaviour of dissimilar weld joints of advanced Cr–Mo–V and Cr–Ni–Mo creep-resistant steels

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ABSTRACT

The influence of hydrogen charging on the room-temperature tensile properties and fracture behaviour of two dissimilar weld joints has been investigated. The weld joints were either ferritic/ferritic (T91/STN15128) or ferritic/austenitic (T91/TP316H). The tensile tests were carried out using the samples with a circumferential notch. The position of notch was individually located in different weld joint regions, either in the heat-affected zones (HAZ) or weld metal (WM). The application of hydrogen charging had detrimental effect on strength and plasticity of the weld joint T91/STN15128. The most significant deterioration of the notch tensile properties was measured for the STN15128 HAZ. The hydrogen charging had only small influence on the strength of the weld joint T91/TP316H but remarkable detrimental effects on the plasticity. In the PWHT state (without hydrogen charging) all regions of the studied weld joints fractured by ductile dimple tearing. The failure initiated on the secondary phase particles and/or inclusions as well. In contrast, the failure after hydrogen charging initiated in the vicinity of sizeable particles and showed a transition from the ductile dimple tearing to the transgranular cleavage and/or quasi-cleavage fracture mode.

1. Introduction

Advanced creep-resistant steels are used for constructing of different parts of steam boilers in energy industry [1]. The structural parts working at different operating conditions are joined by dissimilar welds [2–4]. In many cases, the used filler materials differ vastly from both welded base materials. Such dissimilar welds are commonly denoted as transition welds [2,5,6].

The creep-resistant steels and their weld joints are often subjected to the presence of hydrogen during operation of power plants. The hydrogen effects at high temperatures and pressures may cause the destabilisation of carbides in microstructure of the steels [7]. Moreover, the hydrogen absorbed on dislocations promotes the occurrence of hydrogen embrittlement (HE) at low temperatures [8]. The coarse-grained HAZ in the welds of Cr–Mo–V ferritic steels is known to be the most susceptible region to the HE. The embrittling effects are typically manifested by a significant decrease of plastic properties such as fracture toughness and ductility [7,9]. The coarse-grained HAZ exhibits generally the highest hardness and the lowest toughness in these welds. At the presence of hydrogen and tensile stresses after cooling, the brittle fracture occurs by hydrogen induced cracking (HIC) [8–10].

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