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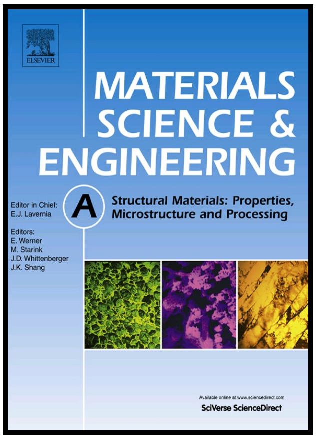

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Evaluation ofStrength Property Variationsacross9Cr-1Mo Steel Weld Joints Using Automated Ball Indentation (ABI) Technique

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Abstract

The variations of strength properties across 9Cr-1Mo steel weld joints fabricated by different arc welding processes such as shielded metal arc welding (SMAW), tungsten inert gas (TIG) and activated tungsten inert gas (A-TIG) have been evaluated employing automatic ball indentation (ABI) technique. ABI tests were conducted at 298 K acrossvarious zones of the weld joints comprising of base metal, weld metal, heat affected zone (HAZ) and intercritical HAZ (ICHAZ) regions.The flow curves obtained from ABI tests were correlated with corresponding conventional tensile test results. In general, the tensilestrength decreased systematically across the weld joint from weld metal to base metal. Inter critical HAZ exhibited the least strength implying that it is the weakest zone. The incomplete phase transformation in the ICHAZ during weld thermal cycle caused the softening. The A-TIG weld metal exhibited higher UTS and strain hardening values due to higher carbon in the martensite. The strain hardening exponent exhibited only slight variation across the various regions of the weld joints. A-TIG weld joint exhibited higher weld metal and HAZ strength, marginally higher UTS to YS ratio in the weld metal and HAZ compared to that of the other two processes.Hence, among the three welding processes chosen, A-TIG welding process is found to be superior in producing a 9Cr-1Mo steel weld joint with better strength properties.

Keywords: 9Cr-1Mo steel, Arc Welding, Automated Ball Indentation, Microstructure, Mechanical properties

1. Introduction

Power plants widely use 9Cr-1Mo steel for thesteam generator and its componentsduring high temperature applications [1]. The plain 9Cr-1Mo steel is suitable for applications in the temperature range 773-823 K. The above steel exhibits good high temperature tensile propertiesand is more resistant to radiation damage than austenitic stainless steels. The 9Cr-1Mo steels also exhibit good creep rupture strength and the details about their creep behaviour can be found else were [2-5]. Low thermal expansion, high thermal conductivity, enhanced resistance to stress corrosion cracking and less susceptibility to thermal fatigue of the above steel make it a promising material for gas turbine, chemical industry and power plants, etc..9Cr – 1Mo steel offers high resistance to void formation during ion, electron and neutron irradiations in the temperature range 673 – 898 K and their good high temperature properties has rendered them suitable for application as fuel element components, such as wrappers, and also in the steam circuitry in the sodium-cooled fast reactors [6,7]. 9Cr – 1Mo steels are being seriously considered for Fast Breeder Reactor (FBR) applications for the following reasons [8]: Acceptable mechanical properties at service temperature, achieved by the fine substructure with a grain size of 0.5 – 2 μm generated during martensitic transformations; Easy control of microstructure and microstructural stability during long term service; Reduced tendency for temper embrittlement due to a lesser degree of segregation of impurity elements; Resistance to decarburization; Better corrosion resistance (stress corrosion cracking); Better oxidation resistance; Excellent resistance to thermal stresses. 9Cr-1Mo steels have been used for superheater components in steam generator circuits and as a wrapper material in the prototype fast reactor in the United Kingdom [8]. Plain 9Cr-1Mo steel is chosen as a candidate material for hexcan wrapper fuel