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Estimation of Residual Stresses by Nanoindentation in an Experimental High Strength Microalloyed Steel Subjected to Rapid Thermal Cycles

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Abstract

The effect of welding thermal cycles on the microstructure and residual stresses was studied in the welding zone of an experimental high strength microalloyed steel with an acicular ferrite and quasi-polygonal ferrite microstructure. Autogenous gas tungsten arc welding was performed on a plate of microalloyed steel to produce a weld bead neglecting the weld joint design and the selection of filler material. To obtain a high welding quality, the welding speed and distance between the electrode and plate was controlled with a small vehicle. To

determine the residual stresses, nanoindentation tests were performed in each one of the welding zones and subzones of the heat-affected zone (HAZ). These results showed that all of the nanoindentations presented pile-up and sink-in, and thus, a modification was proposed to calculate the actual contact area and determine the residual stresses. Tensile residual stresses were presented in the coarse-grained HAZ (grain boundary ferrite, acicular ferrite, and bainite); fine-grained HAZ (polygonal ferrite); subcritical HAZ (acicular ferrite and quasi-polygonal ferrite); and base material (acicular ferrite and quasi-polygonal ferrite). The fusion zone (acicular ferrite and bainite) and intercritical HAZ (quasi-polygonal ferrite) had compressive residual stresses.