Effect of Heat Treatment Temperature and Time on Residual Stresses in Welded Ar200 Steel Structural Bars

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AR200 steel is an abrasion resistant carbon-manganese steel with a typical hardness of ~150 HB. The material is frequently welded to fabricate complex structural components (e.g., custom-built auto bodies) due to its economic attractiveness. However, the AR200 steel contains elevated amounts of Manganese (Mn), Silicon (Si) and Carbon (C), leading to Carbon equivalent (C_e) of 0.42wt%, which makes it a difficult material to weld.

In this research, AR200 C-sections were welded using MiG technique and heat treated at 400 – 800 ºC temperatures for duration of 2 – 6 minutes. Mechanical testing was performed on welded samples to study the effect of heat treatment on the tensile strength and hardenability of the material. Further, the influence of the treatment temperature and time on the AR200's microstructure was studied using optical microscopy with quantitative image analysis and SEM-XEDS techniques.

Statistical analysis of the results confirmed that the tensile strength of the AR200 steel was significantly influenced by the heat treatment procedure. Figure 1 summarizes the results of tensile testing and jominy hardenability test. Clearly, the ductility of the material can be significantly affected by heat treatment temperature. Further, localized microstructure modification as a result of heat treatment may be significant (hardenability distance exceeded 1").

The microstructure of the AR200 steel was fully characterized and the results suggest that martensite, which was initially present in the as-received AR200 steel bars, can be effectively manipulated by tempering above 500°C.

Residual strain mapping of welded and heat treated AR200 sections was carried out using neutron diffraction along several linescans in three orthogonal directions. The results of neutron diffraction strain mapping revealed unique trends for residual strain on either side of the welded region. The key preliminary observations for the three measurement directions are summarized in the following text.

For the x direction (Weld location at 70 – 87 mm):

1. With increase of heat treatment time, higher tensile x-strain evolved.
2. A stress concentration evolved in the weld (with tension on either side of the weld)
3. Partial homogenization occurred with increase of HT time

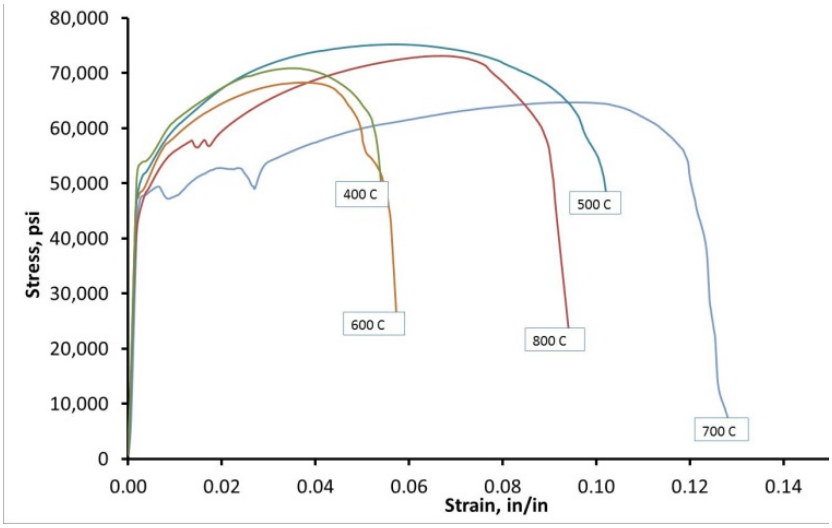
For the y- direction (Weld location at 70 – 87 mm):

1. Tensile y-strain developed in the middle of the weld with adjacent compressive y-strain
2. Non-symmetrical profile due to c-section geometry of the structural bar (higher tension is "thin section") on either side of the weld

Compression in z-direction (through thickness)

1. Clearly visible strain concentration in the Z-strain was observed in the weld
2. Part thickness was the same before/after weld, and the levels of residual strain before/after appeared to be similar in magnitude

The research results have been presented at the 2013 Materials Science and Technology (MS&T) international conference, held in conjunction with the Conference of Metallurgists (COM2013) in Montreal.



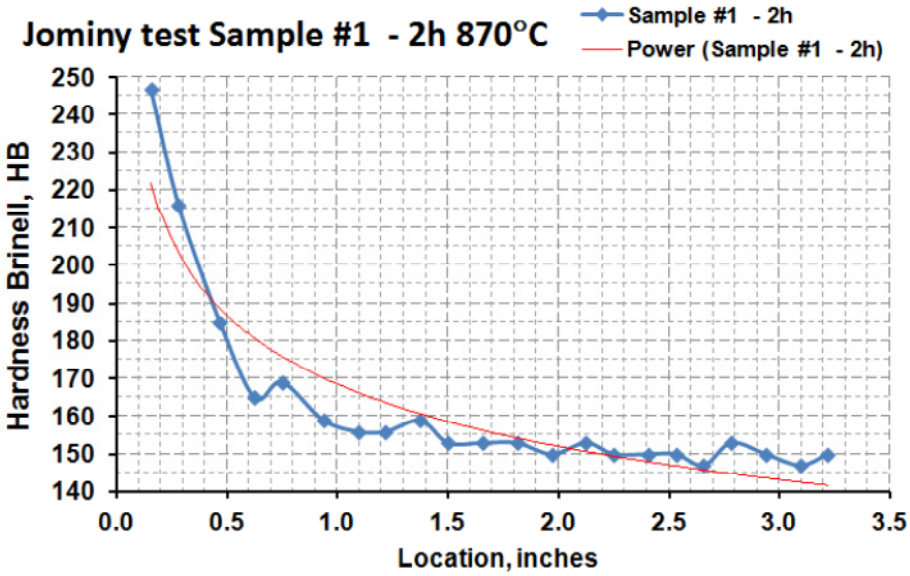


Figure 1 Representative results of mechanical testing and Jominy hardenability test

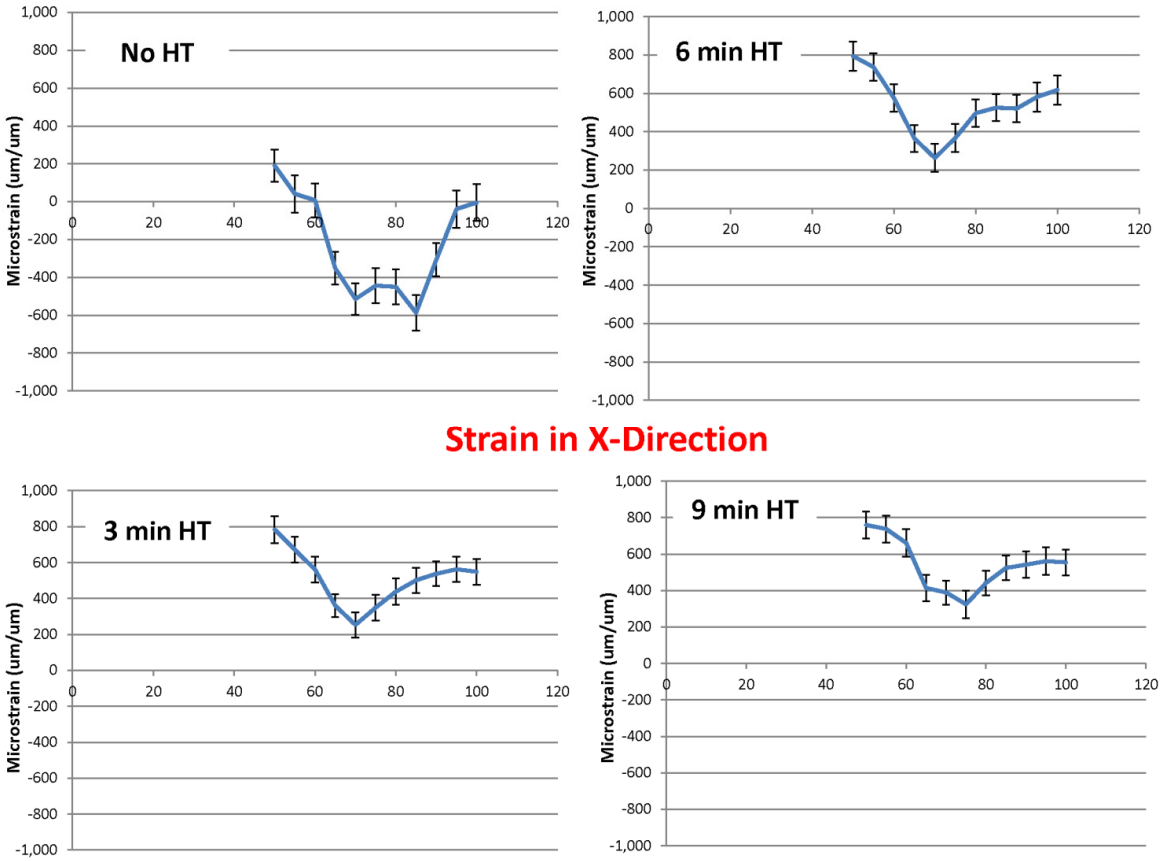


Figure 2 Strain in x-direction

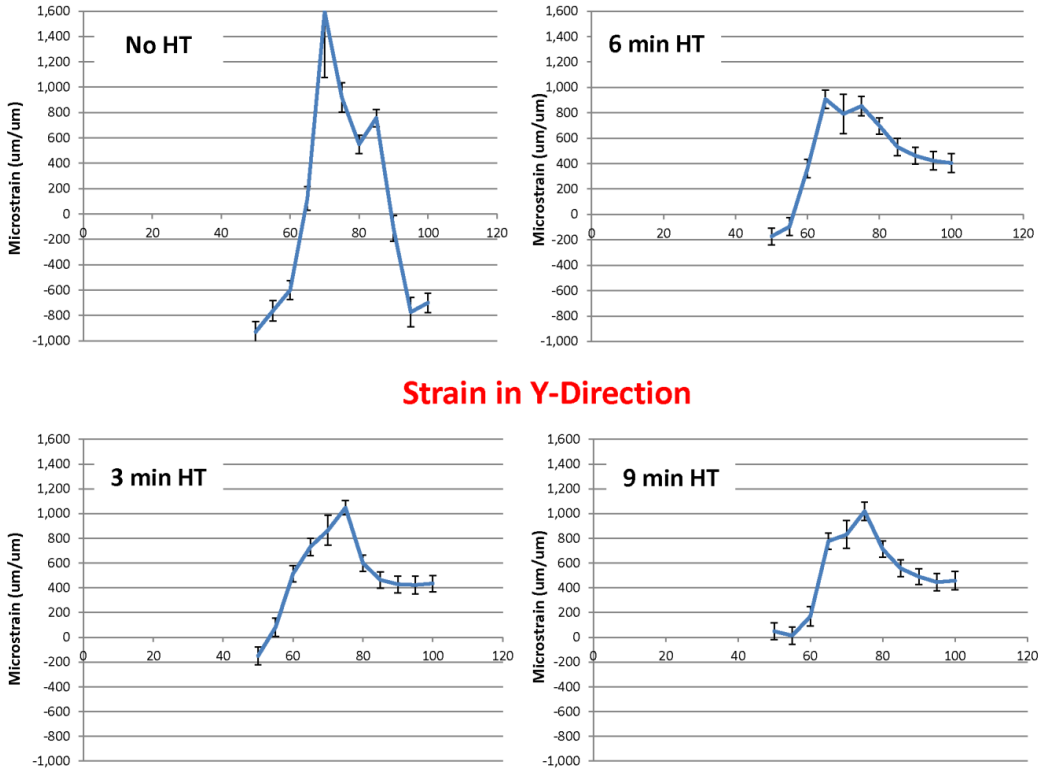


Figure 3 Strain in y-direction

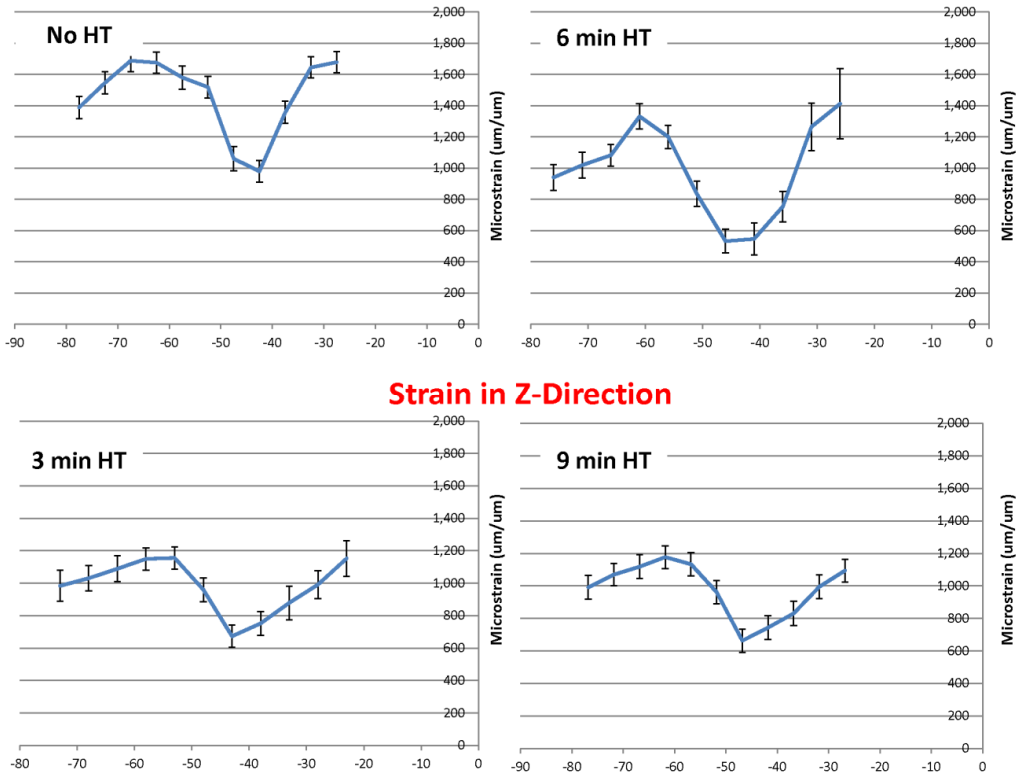


Figure 4 Strain in z-direction