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Fractography of CTOD Specimens in Welded Joints of $2^1/_4$Cr-1Mo Steel

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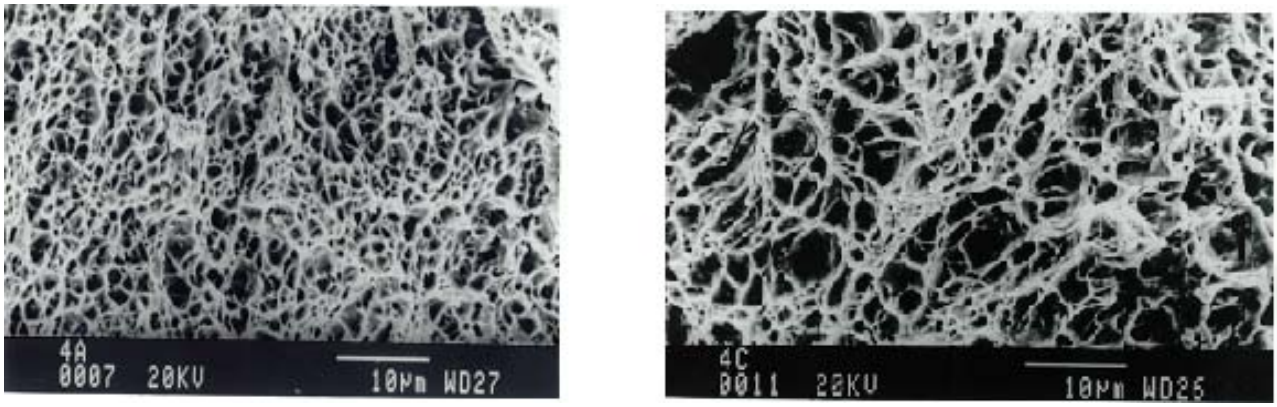
Fracture toughness ($CTOD_m$), at room temperature was evaluated in welded joints of $2^1/_4$Cr-1Mo steel, which were submitted to temper embrittlement simulation by means of "Step Cooling" (SC) with and without stress, at coarse grain (CGHAZ) and fine grain heat affected zone (FGHAZ) and at weld metal (WM) by Zumpano [1]. This work analyzed $CTOD_m$ specimens by means of scanning electron microscopy (SEM) to help on fracture characterization of specimens of Zumpano [1], at region of stable growth of crack. Analysis and records of specimens at CGHAZ, FGHAZ and weldmetal were made in specimens submitted to SC with and without stress. Specimens of HAZ without SC were analyzed without record. Fractographic analysis reveals that fracture micromechanism was microvoids coalescence at region of crack stable growth in all different analyzed conditions. Figure 1 shows the aspect at SEM of the samples 4A and 4C at region of crack stable growth, respectively in FGHAZ and CGHAZ submitted to SC without stress. Figure 2 shows the same for the samples 3A and 2D, respectively in FGHAZ and in MS, submitted to SC with stress. Figure 3 shows general aspect of crack plane of CTOD specimen. The fracture mechanism is an important parameter to evaluate the simulation efficacy of SC, and it depends on the test temperature. The change of the fracture mechanism from microvoids coalescence to intergranular, characteristic of temper embrittlement, observed by Teixeira et al [2], just in temper embrittlement simulations where there were stress associated with SC's treatment, was not observed in this work. Teixeira et al [2] evaluated MS made by SMAW, while in Zumpano's work [1] the MS analysed was made by SAW. The Charpy tests temperatures of Teixeira et al [2] were 30°C and 0°C and the temperature of Zumpano [1] CTOD tests were between 23°C and 23,5°C. Differences in the regions and test temperatures complicate comparisons, but give an indicative of the fracture toughness of HAZ of this steel at room temperature. Hardness tests and microstructural observations of Zumpano [1] proved that the stress associated with SC accelerated embrittlement, improving the simulation efficacy. The impurities control avoided temper embrittlement in this steel. It was not detected significant $CTOD_m$ values variation between different analyzed situations. These results and observations at SEM confirmed the good behavior of fracture toughness of HAZ's of the $2^1/_4$Cr-1Mo steel studied, at room temperature.

References

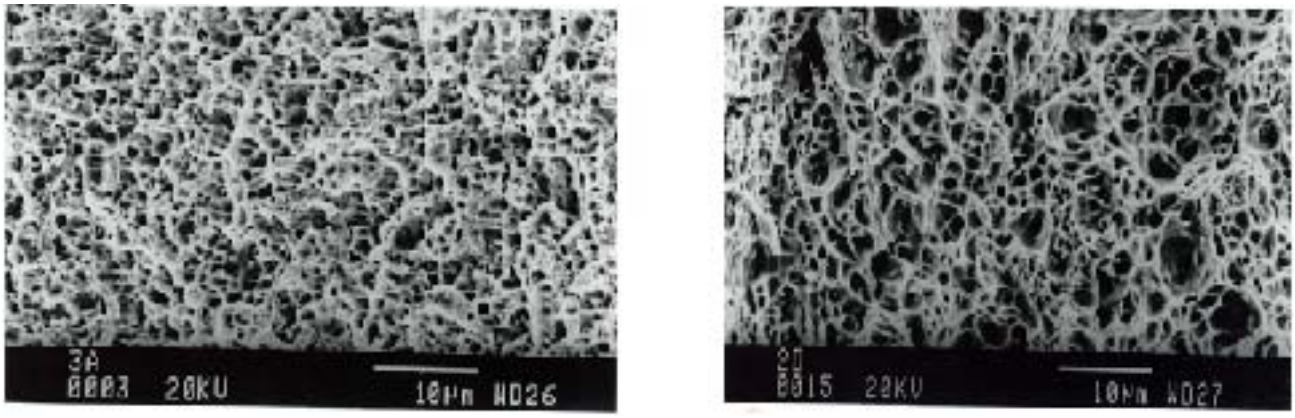
[1] – Zumpano Jr., P. *Tenacidade à Fratura na ZAC de Aços 2,25Cr-1Mo.* Campinas-Brazil: UNICAMP, Jan 2003, 129 p. Dissertation (Master of Science)

[2] - Teixeira, J, C. G., et al, *Efeito da tensão no mecanismo de fragilização pelo revenido de metal de solda de aço 2,25Cr-1,0Mo*. XXII Encontro Nacional de Tecnologia da Soldagem, ABS, 1996, v.1, pp. 1-11.



(a) Sample 4A –FGHAZ– with SC without stress (b) Sample 4C –CGHAZ– with SC without stress

Figure 1: Fractography of fracture surface of $CTOD_m$ specimens, crack stable growth region.



(a) Sample 3A – FGHAZ – with SC with stress (b) Sample 2D – MS – with SC with stress

Figure 2: Fractography of fracture surface of $CTOD_m$ specimens, crack stable growth region

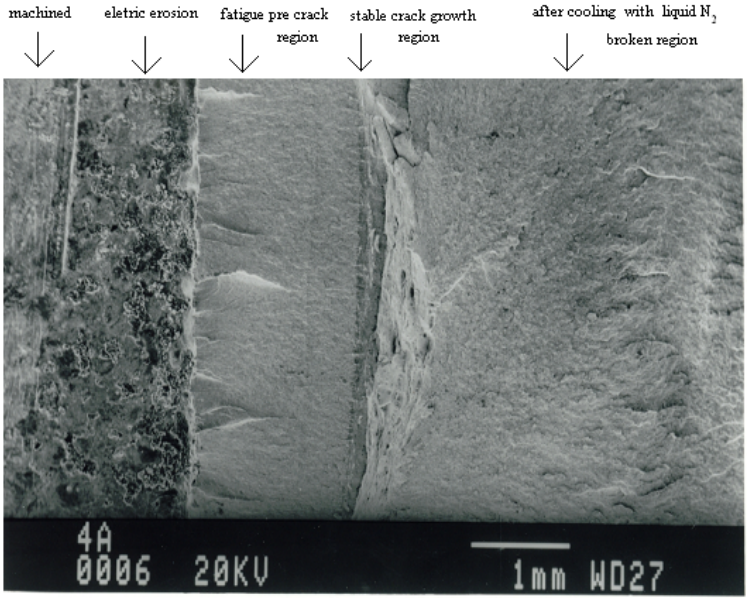


Figure 3: Fractography of fracture surface of $CTOD_m$ specimens, all regions. Sample 4A.

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