inducement of compressive residual stress in the weld metal was able to increase the fatigue strength. Butt-welded flat tensile specimens of treated and non-treated cases were prepared according to DIN 50 120-Part 1 specifications and tested to find tensile properties at a strain rate of 0.5 mm/min. In all cases, the fracture occurred in the weld metal. The type of fracture was ductile. The yield strength, ultimate tensile strength and elongation values for both cases are given in Table 4. It can be seen that the tensile properties do not change due to cryogenic treatment.

3.4. Fractography

Fig. 8 shows SEM fractographs of crack initiation regions of treated and non-treated specimens. In the case of treated samples [Fig. 8(a)], the observation of large numbers of facets and secondary cracks could be associated with the martensitic transformation. Because of the non-uniform microstructure, local stresses may be concentrated at these locations and may cause secondary fatigue cracks to initiate [15]. The crack branching and deflection reduces the stress concentration factor of the primary crack and crack initiation takes longer. In both cases, ductile type striations (stage II crack growth) were observed and the crack propagation mode was transgranular. When final separation and fracture commences (stage III), the specimens fail in the root, exhibiting dimples as shown in Fig. 9 which are indicative of ductile tearing.

4. Conclusions

This work presents the findings of a study of the axial fatigue performance of AISI 304L load-carrying cruciform joints which failed in the weld metal with and without cryogenic treatment. The fatigue properties of cryogenically treated samples have shown improvement. The strain-induced martensites formed during the cryogenic treatment and the associated generation of compressive stresses in the weld metal are considered to be effective in fatigue life extension of welded joints in the high cycle regime.

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References

[1] Frank KH. The fatigue strength of fillet welded connections. PhD thesis, Lehigh University, October 1971.
[2] Satoh K. Thermal stresses developed in high-strength steels subjected to thermal cycles simulating weld heat affected zone. Trans JWS 1973;3:135–42.
[3] Lawerance FV, Radziminski JB. Fatigue crack initiation and propagation in high yield strength steel weld metal. Weld Res 1970; 10(Suppl.):445s–52s.
[4] Maddox SJ. Resent advances in the fatigue assessment of weld imperfections. Weld J 1993;7:42–52.
[5] Diekman Rick. Cryogenics in the thermoset molding industry. Thermosettings. The Journal of the Thermoset Division 2001; 29(2):5–14.
[6] Jack R, Price AT. The use of crack initiation and growth data in calculation of fatigue lives of specimen containing defects. Metal Const 1971;3:416–9.
[7] Testin RA, Young JY, Lawrence FV, Rice RC. Predicting the fatigue resistance of steel weld metals. Weld Res 1987;(Suppl 4): 93s–8s.
[8] Xiulin Zheng. A further study on fatigue crack initiation life-mechanical model for fatigue crack initiation. Int J Fatigue 1986; 8(1):17–21.