

Improvement of Fatigue Strength in Non-Load-Carrying Cruciform Fillet Welded Joint by Weld Metal Phase Transformations

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Generally, tensile residual stresses are induced around a weld toe due to weld metal contraction during cooling. As consequence, fatigue strength of the welded joint is deteriorated. Post-weld heat treatment and shot peening are often carried out to remove the tensile residual stresses. Low transformation temperature welding wires (LTTW) such as a 10%Cr-10%Ni wire, which can induce compressive residual stresses through martensitic transformation, have been developed to increase the fatigue strength. In this paper, several LTTW's with chemical compositions and transformation temperatures different from the 10%Cr-10%Ni wire have been designed by researchers of the Colorado School of Mines and investigated to characterize the effect of phase transformation on residual stress management in welded joints.

These designed wires transform into martensite structures between 390 and 270 °C while the commercial wire transforms into ferrite structure at 645 °C. Due to the transformation behaviors, extensive strains are detected for the designed wires in the dilatometric analysis. On the contrary, contractive strains are measured for the commercial wire.

Non-load-carrying cruciform fillet welded joints were prepared with GMAW for fatigue testing. As shown in Figure 1, fatigue properties of the designed wires named A6, B5 and C5 were enhanced compared to the commercial wire (ER70S-3). According to finite element analysis results, the designed wires had the higher compressive residual stresses at the weld toe in the transverse direction than the commercial wire. In addition, they had the lower tensile residual stresses in the longitudinal direction. These outcomes support the fatigue test results. The fatigue properties of the designed wires were essentially similar to those of the 10%Cr-10%Ni wire. These results indicate that the leaner alloyed, thus more economical, wires can achieve the high fatigue properties as the more expensive wires.

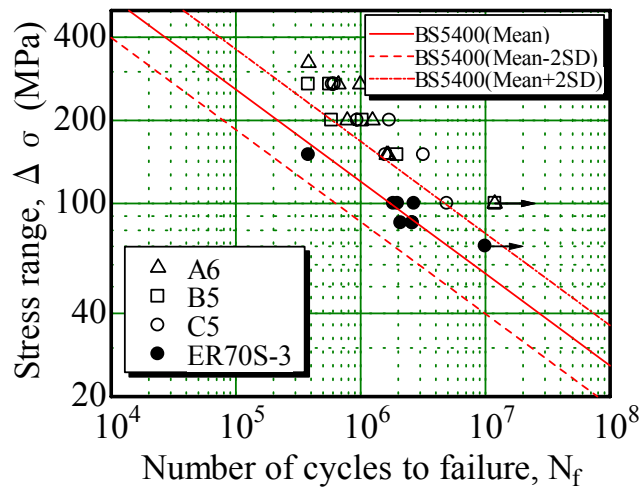


Figure 1. Fatigue test results with BS5400 design curves