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Fatigue life improvement of AISI 304L cruciform welded joints by cryogenic treatment

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Abstract

Existing theories and reported practical experience show that cryogenic processing greatly increases abrasion resistance and contact fatigue resistance of some metals and alloys. In the present work, an attempt has been made to investigate the effect of cryogenic treatment on the axial fatigue performance of fillet welded cruciform joints of AISI 304L stainless steel, which failed in the weld metal. Constant amplitude fatigue experiments with $R = 0$ were carried out with a 100 kN servo-hydraulic DARTEC universal testing machine with frequency of 30 Hz. It has been observed that after the deep cryogenic treatment at liquid nitrogen temperature (−185 °C), the fatigue life improved almost by a factor of two. During the treatment the significant microstructural changes that occurred accounted for the improved fatigue performance. Strain induced martensitic transformation was observed. During this transformation, the weld metal tends to expand inducing compressive residual stresses in the weld metal.

Keywords: Weld fatigue; Cruciform joint; Welded fabrications; Cryogenic treatment; Residual stress

1. Introduction

Fillet welded cruciform joints of stainless steel are the most common in various structures including offshore and nuclear applications. The fatigue strength of welded structures is inferior to those of the base metal partly due to high tensile welding residual stress of yield strength magnitude [1] in the weld metal. The high tensile residual stresses are induced in weld metal as it contracts during cooling [2]. The important variables in determining the fatigue life of a flawed weldment would seem to be the nature of internal flaws contained within the weld and the manner in which these flaws interact within the stress field in and around the weld during its fatigue life [3]. Many of the fatigue failures that occur in welded joints involve fatigue cracking from severe imperfections, which are actually an inheritance of the joint [4].

There are two types of fatigue cracking in cruciform joints: (a) root cracking and (b) toe cracking. In welded cruciform joints, the lack of penetration (LOP) occurs in the joint due to the lack of access to the

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