

A NOVEL METHOD FOR EVALUATING PLANE STRESS DYNAMIC FRACTURE TOUGHNESS OF 0Cr18Ni10Ti STAINLESS STEEL WELDED JOINTS

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A novel method was proposed for the evaluation of Mode I dynamic fracture toughness (DFT) under plane stress and small scale yielding conditions for welded joints of stainless steel (SS), 0Cr18Ni10Ti. In a hybrid experimental-numerical approach, the experiments were carried out on the Hopkinson pressure bar apparatus, and three dimensional (3D) transient numerical simulations were performed by a finite element (FE) computer program. Macroscopical plastic deformation was observed at the loading and supporting points, on the specimens, after the test, which could cause a large error if omitted in the numerical simulation. Therefore, elastic-viscoplastic analysis was performed on the specimen by adopting the Johnson-Cook (J-C) model to describe the rate-dependent plastic flow behavior of the material. The material heterogeneity in the mismatched welded joints, induced by the difference in the base metal (BM) and the weld metal (WM) in yield stress, has also been taken into consideration by using the J-C models separately. Good accordance was obtained between the experimental and the computational results by the present approach. The relationship between plane stress DFT and loading rate was also obtained on the order of $10^6 \text{ MPa}\cdot\text{m}^{1/2}\cdot\text{s}^{-1}$.

KEY WORDS 0Cr18Ni10Ti; Welded joint; High strain rate; Dynamic fracture; Plane stress

1. Introduction

0Cr18Ni10Ti is a special austenitic SS, which is especially suitable for the fabrication of the piping system in the main circulating circuit (MCC) and a variety of equipment in the power, chemical, petrochemical, and nuclear industries because of its excellent ductility, corrosion resistance and reasonable weldability. In the design and safety assessment of such structures, fracture resistance of the heat affected zone (HAZ) in the BM and its welded joints is of great importance, because of the specialties of the material and its application. Rapid heating and cooling and the filler material fusion into the WM often leads to uneven properties of metallurgy and mechanics in the welded joints, even if the filler metal is the same as the BM^[1]. The thermal effects associated with the welding process generally cause a structure to fail at its welded joints^[2]. On the one hand, filler metals with higher yield strengths compared to a BM are commonly chosen by designers, who have in mind

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the shielding effect of strength overmatching the weldment fracture behavior, and such a weldment can be a critical one for structural integrity because of possible unstable fracture behavior^[3,4].

In the mid 1980s, it was stated by the American Institute of Mechanical Engineers that for welded joints from austenitic steels, produced by manual arc welding and submerged arc welding, the assessment of their fracture resistance should be based on the mechanism of instable tough tearing, because these materials often had lower toughness and were characterized by crack increment under loading, before critical load achievement^[5]. On the other hand, it had been found that any interaction between two adjacent WM matrix and soft WM inclusions produced local brittle zones (LBZ), causing local unstable fracture behavior^[4]. The occurrence of a brittle fracture depends on the toughness of the WM and the HAZ, which is generally lower than that of the BM^[6].

Material heterogeneity of a weldment can be presented by the comparison of tested Charpy V-notch specimens for the BM and the WM of 0Cr18Ni10Ti SS welded joints, as shown in Fig.1. The BM presents very high toughness in the tests, in that, all the specimens are only bent and torn at the notch, but none is completely broken. On the contrary, all the specimens for the WM are broken in two under impact load along the notch, which is located at the center of the welded joint. The result shows that the WM is brittle and has much lower toughness than the BM. The brittleness of the WM implies that the capability of fracture resistance of this material is low and it can be very dangerous for the structure, under impact load. Therefore, the safe usage of structures containing welded joints often requires complete fracture behavior investigation and determination of fracture resistance. General yielding or linear elastic fracture mechanics tests are recommended to be carried out on welded joints, and minimum toughness must be specified on the basis of the the largest defect that can remain undetected in the structure^[7,8].

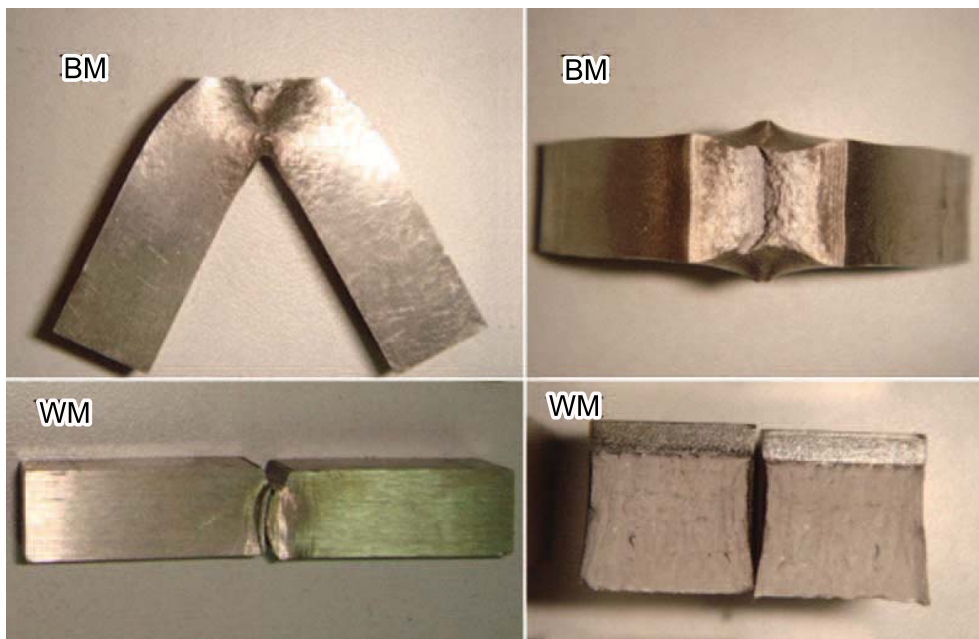


Fig.1 Comparison of tested Charpy V-notch specimens for the BM and the WM.

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