Fracture Aspects in Testing Welds

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Abstract. For weldments, the paper is specialized in fracture testing. As well, the effect of specific weld characteristics on concept of test issues is given. Especially, consideration is paid to the effect on testing of some of the attributes such as experiments on definite microstructural zones, elimination of both residual stress influences on fracture toughness measurement and misalignment effects. It is also addressed determination of crack growth and weldment tensile qualities.

Introduction

Fracture toughness testing of weldments is focused on the effect of definite mictrostructural zones and elimination of both residual stress influences on fracture toughness measurements and misalignment effects (Fig.1). Characteristic specimens for discussed testing are stated (Figs 2,3). It is worthwhile to recall the advantages of testing specific microstructures by shallow notched specimens, when applying *K*, *J* integral and *CTOD* solutions [1]. An extra to conventional testing stand for the choice of the notch location in connection with test metallography and the possible necessity to modify the residual stress state before or in the course of pre – cracking. A knowledge of the various parameters influence is essential so as to achieve conservative limitations in structural assessment and testing.

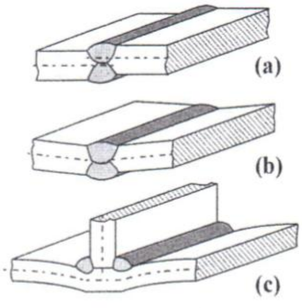

Fig. 1 Axial and angular misalignment illustrations

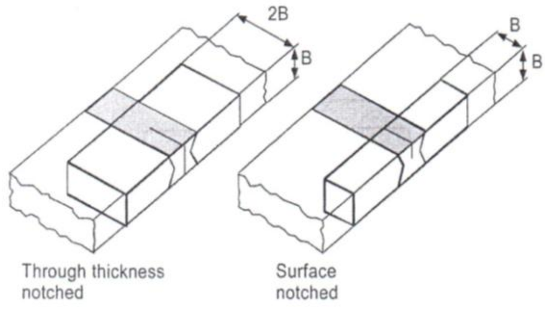

Fig. 2 Through – thickness and surface notched specimens [1]

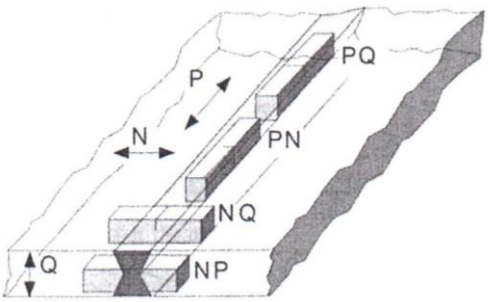

Fig. 3 Ranking for specimen outlook regarding the weld axis [3]

Testing definite microstructures

The purpose is to stipulate the fracture toughness as regards crack initiation or extension for a characteristic target region, for example the weld centre line, the heat affected zone, and characteristic microstructure, eg coarse grainy affected zone. Welded joints that depict some linear misalignment or angular torsion should be straightened before testing [2]. This is made by local bending of the specimen ends to local bending moments owing to misalignment and reinforcement in the construction must be taken into account at the applied side, that is, while stipulating the crack driving force in the component [3].

Elimination of weld misalignment

Before fatigue pre – cracking, it may be essential to alter the welding residual stresses in the specimen prior to testing. There are some stimulations. The welding residual stresses demonstrate an inhomogenous design over the section which may affect fatigue crack growth in the way that the pre – crack front will evolve an irregular form.

The residual stresses are in part relieved and redistributed owing to the extraction of the specimen and the insertion of the crack initial notch, the remaining residual stresses may even be large enough to considerably affect the shape of the pre – crack front and the outcome of the fracture toughness test. An evident technique for residual stress relief is post – weld heat interpretation.

Pre – cracking

In the course of local compress before pre – cracking, hardened steel plates are pressed on one or both side surfaces of the specimen over 86 – 92 % of the ligament ahead of the crack tip thus that a plastic strain of 1 % of the specimen thickness is put out [4]. The reverse bending method did not obtain its line into the standards as it is considered like relatively wasteful in both, the decrease of residual stresses and setting up of a straight crack front. The stepwise high R – ratio technique is consisted of two steps of pre – cracking for different R – ratios. Usually, no pre – treatment of the specimens is essential for welds that have been post – weld heat handled for the reason of stress relief. The ISO test standard advices the application of the shortest fatigue crack length allowed in the document ISO 12135 for the purpose to minimize crack front curving and also crack deviation from the precise target zone analyses.

Predicting crack initiation and propagation lifespans in butt welds

The crack actions in fatigue that initiate at the toe of a butt weld usually involves two main phases: (i) the crack initiation life (N_i) and (ii) the crack propagation life (N_p) [5]. The initiation period consists of the cycles indispensable to shake down the residual stresses in the weld. The crack propagation period consists of two trajectories (1) through thickness (N_{px}) and (2) transverse (width direction) (N_{py}). The notched – root stress method is employed to estimate the crack initiate life, whilst the fatigue crack propagation lives were estimated applying fracture mechanics interpretation [6], [7]. The experiments were performed for Grade AISI 304L Stainless Steel (analogous to the Grade CSN 17 249), with constant amplitude and stress ratio $R = 0$. The analysis confirms that the crack growth parameters are dependent on the crack propagation courses for the same material. Butt welds tested in fatigue with their reinforcement intact demonstrate less fatigue resistance than flat plate or butt welds with reinforcement removed owing to the notch associated with the toe of the weld.

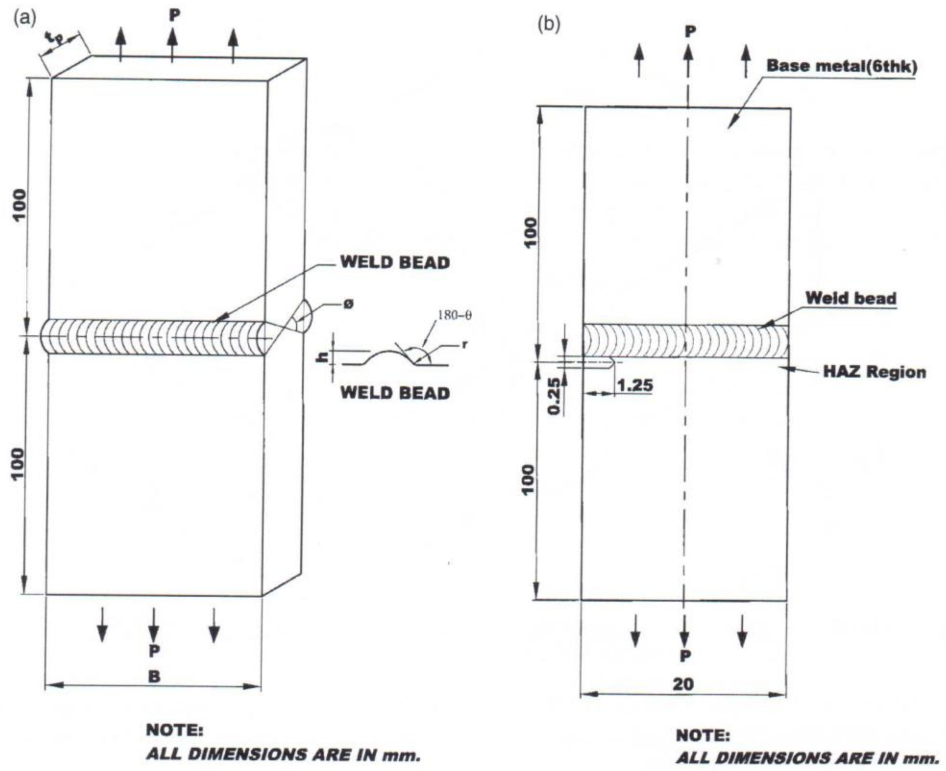

Fig. 4 Particulars of specimens: (a) without notch, (b) with notch [5]

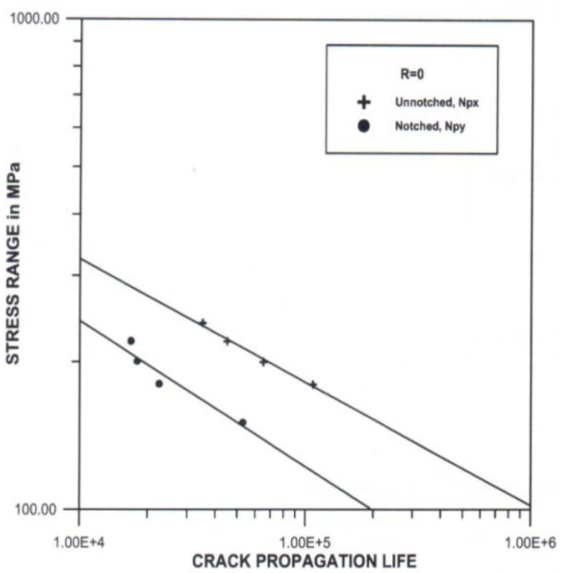

Fig. 6 Crack propagation lifespans of unnotched and notched specimens [5]

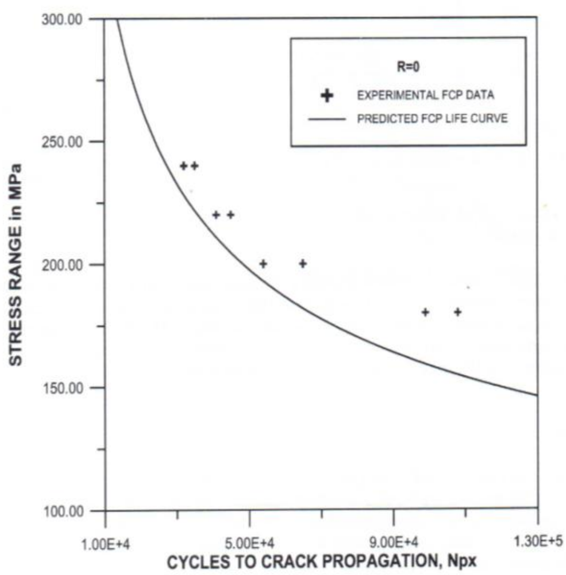

Fig. 7 Comparison between the predicted curve for fatigue crack propagation lifespan and test data for unnotched specimens

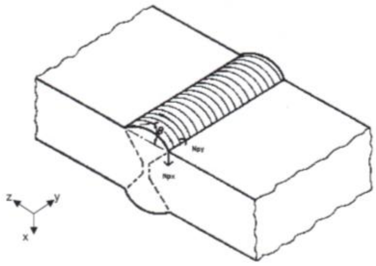

Fig. 5 Crack propagation trajectories in butt-welded joints

Conclusion

Both, the fracture toughness and determination of stress – strain dependences for heterogenous samples, namely for notched test bar weldmens, are outlined. To predict the fatigue crack propagation lifespan in the *y* – direction (N_{py}) of the butt welds, a new test routine employing fracture mechanics outlooks is summarized. The fatigue crack initiation and propagation lifespans of the stainless steel butt welds under constant amplitude load can be to a considerable degree predicted. Since the mictrostructure alongside the crack trajectory and the stress concentration factor are exceedingly different for unnotched and notched specimens, the fatigue crack propagation properties change in both cases for the same material.

Acknowledgment

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