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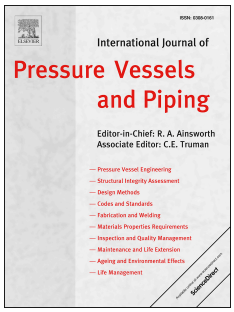

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Effective notch stress approach for welds having low stress concentration

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Dedicated to Prof. (em.) Dr.-Ing. habil. Eckart Weiss, Technical University Dortmund, for his 75th birthday and in appreciation of his work in improving the safety of pressure equipment.

Abstract

The effective notch stress approach for fatigue assessment of welded joints according to the IIW-recommendations is a widely accepted procedure and has already become part of many technical rules and guidelines. The method provides additional means for evaluation of welded joints besides classical nominal and structural stress concepts. In contrast to the latter concepts, effects of many local weld parameters can only be studied analytically using the effective notch stress approach. The effective notch stress approach requires use of a standardized idealization of the weld detail and use of continuum mechanics theory for stress analysis (i.e. use of solid elements for finite element models). The idealization with respect to geometry includes modeling of all weld toes and weld roots using a reference radius together with an associated S-N curve. For joints facing low stress concentration, like butt welds or welds at thin sheets, the method requires checking the fatigue behavior of the base material as well. This sometimes is not considered in using the effective notch stress method, because it is not so obvious. Explanation of background information and a reanalysis of an example from literature is presented here for explanation and demonstration of this concept and of specific needs for welds with low stress concentration. Also the selection of the size of the reference radius will be discussed in this paper by using different radii for the case investigated here. Finally the application limits of the S-N curves as given in the IIW-recommendations is discussed since the selected example is slightly out of the range of application of the S-N curves.

1. Introduction

1.1 Effective notch stress approach

The effective notch stress approach covers notch effects from weld roots and weld toes, which both might be responsible for the fatigue behavior of welded joints. Using a reference radius and usually also idealized weld flanks as a rule for modeling the joint for stress assessment, effective notch stresses can be calculated using linear elastic material behavior. For assessment of the fatigue life, a single S-N curve can be used for each material group (i.e. steel, aluminum, magnesium) and basic loading condition (i.e. pure normal stress acting along weld seam or pure shear stress). This standardizes the calculation of welded joints and minimizes further interpretations and decisions by the analyst. This fatigue curve contains mean value and scatter of the fatigue behavior of welded joints and is usually given for a certain (low) failure probability (i.e. P_f = 2.3% in [1]).

The effective notch stress approach, as described in the IIW-recommendations for fatigue assessment of welded joints [2], [1] including guidelines [3], is based on research by Seeger and co-workers (Olivier et al., 1989 und 1994, Köttgen et al., 1991, Seeger et al., Olivier, 2000; [4] to [8]). Today the effective notch stress approach has been adopted by multiple guidelines and technical rules, i.e. guidelines by the International Institute of Welding (IIW) [2], [1], DVS Germany [9] and the internationally acknowledged FKM-guideline from Germany [10]. The current state-of-the-art regarding this approach is described in the following, including several important details for correct application.

For usual weld seams with a nominal thickness above 5 mm, a reference radius of 1 mm should be applied. This gives a good compromise for accuracy versus computational effort. Small weld seam cross sections and thin welded sheets require smaller values for the reference radius.