Application of Design Concepts at High Frequency Hammer Peened Welded Ultra High Strength Steels

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Summary

Within fatigue tests carried out at the Institute for Metal and Lightweight Structures of the University of Duisburg-Essen, the influence of the post weld treatment method high frequency hammer peening (HFHP) on the fatigue strength of welded ultra high strength steels (UHSS) S960, S1100 and S1300 has been determined. The test results of the HFHP-treated specimens showed a significant improvement of the fatigue strength with an increase of the slope of the S-N-line to approximately m ~ 5 compared to the as welded condition. Up to now, fatigue design rules and recommendations for welded and HFHP-treated joints are limited to maximum steel grades of S960 and plate thicknesses of at least 5 mm. Within this contribution, the application of the structural hot spot stress and effective notch stress design concept to as welded and HFHP-treated weld toes of UHSS with rather lower plate thicknesses has been approved using numerical finite element analysis.

Keywords: high frequency hammer peening, post weld treatment, fatigue life improvement, ultra high strength steel, fatigue design, structural hot spot stress, effective notch stress.

1. Introduction

The use of ultra high strength fine grained structural steels (UHSS) in welded, fatigue loaded structures is only reasonable for applications with high dead loads or high stress ranges as the fatigue strength of welded joints is nearly independent from the yield strength. The application of post weld treatment methods can improve the fatigue behaviour of welded joints. In particular, methods like high frequency hammer peening (HFHP), which modify the residual stress state locally, are suitable for the fatigue strength improvement of steels with high yield strengths. For this reason, the Institute for Metal and Lightweight Structures has performed fatigue tests at different notch details of welded UHSS to determine the influence of HFHP on the fatigue strength. The results of this fatigue tests have been evaluated by nominal stress design approaches which are published by the authors in detail in [1-2]. Beside the widely used nominal stress design concept, further numerical based or local approaches like the structural hot spot stress and effective notch stress approach exist for fatigue design of welded joints. Therefore, numerical investigations have been performed to prove the applicability of these concepts to as welded and HFHP-treated specimens of UHSS with rather low plate thicknesses investigated in [1-2].

2. State of the art

2.1 High frequency hammer peening (HFHP)

HFHP is a local post weld treatment method which plastically deforms the weld toe surface resulting in cold hardening of the near surface region and rounding of the weld toe, see figure 1. HFHP modifies the residual stress state of the treated weld toe by inducing compressive residual

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