HÖGSKOLAN VÄST

Improving Fatigue Properties of Welded High Strength Steels

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AKADEMISK AVHANDLING

som med tillstånd av Forsknings- och forskarutbildningsnämnden
vid Högskolan Väst, för avläggande av doktorsexamen i Produktionsteknik,
framläggs för offentlig granskning.

Onsdagen den 6 september 2017 klockan 9.15 i F104, Högskolan Väst

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Abstract

Title: **Improving fatigue properties of welded high strength steels**

Keywords: Fatigue strength; Residual stress; Welds; Weld toe geometry; High strength steel; High frequency mechanical impact treatment; Low Transformation Temperature welding consumable

ISBN 978-91-87531-60-6 (Printed)
ISBN 978-91-87531-59-0 (Electronic)

In recent years a strong interest has been expressed to produce lighter structures. One possible solution to reduce the weight is to utilize high strength steels and use welding as the joining method. Many components experience fatigue loading during all or part of their life time and welded connections are often the prime location of fatigue failure. This becomes more critical in welded high strength steels as fatigue strength of welds does not increase by increasing the steel strength. A possible solution to overcome this issue is to use fatigue improvement methods.

In this thesis the effect of two fatigue strength improvement techniques: high frequency mechanical impact (HFMI) treatment and use of Low Transformation Temperature (LTT) consumables have been investigated. In this regard, Gas Metal Arc Welding (GMAW) was used to produce butt and fillet welds using LTT or conventional fillers in steels with yield strengths ranging from 650-1021 MPa and T-joint welds in a steel with 1300 MPa yield strength. Butt and fillet welds in 650-1021 MPa steels were fatigue tested under constant amplitude tensile loading with a stress ratio of 0.1 while T-joints were fatigue tested under constant amplitude fully reversed bending load with a stress ratio of -1. Residual stresses were measured using X-ray diffraction for as-welded and HFMI treated welds. Neutron diffraction was additionally used to investigate the near surface residual stress distribution in 1300 MPa LTT welds.

Results showed that use of LTT consumables increased fatigue strength of welds in steels with yield strengths ranging from 650-1021 MPa. In 1300 MPa yield strength steel, similar FAT of 287 MPa was observed for LTT welds and 306 MPa for conventional welds, both much higher than the IIW FAT value of 225 MPa. Neutron diffraction showed that the LTT consumable was capable of inducing near surface compressive residual stresses in all directions at the weld toe. It was additionally found that there are very steep stress gradients both transverse to the weld toe line and in the depth direction, at the weld toe. HFMI increased the mean fatigue strength of conventional welds in 1300 MPa steels about 26% and of LTT welds by 13%. It increased the weld toe radius slightly but produced a more uniform geometry along the treated weld toes. It was concluded that the residual stress has a relatively larger influence than the weld toe geometry on fatigue strength of welds. This is based on the observation that a moderate decrease in residual stress of about 15% at the 300 MPa stress level had the same effect on fatigue strength as increasing the weld toe radius by approximately 85% from 1.4 mm to 2.6 mm, in fillet welds.