Determining the Fatigue Life of Seam-welded joints in Hot Finished Welded Rectangular Hollow Sections

P.D. Hanna[1a], C.M. Davies[1]

[1]Department of Mechanical Engineering, Imperial College London, United Kingdom

[a]peter.hanna18@imperial.ac.uk

Abstract. Hot finished EN10210 [1] hollow sections have been used extensively in construction, cranes, machinery and trailers for many years, but now they are being used in more cyclic loading conditions. The fatigue life of the seam-welds in these sections is becoming more and more important to determine failure over time. The tubes being discussed are fine grain 355NH steel. The aim here is to determine the weld characteristics and whether they can withstand fatigue loading.

Introduction

Rectangular hollow sections are produced primarily by two different methods, seam-welded and seamless processes. The seamless tube has often been the preferred product for fatigue but more are selecting the full body normalised NH as an alternative. Those evaluated here are seam-welded, hot finished tubes. The hot finishing allows for much tighter corner radii compared to a cold formed tube and as such is more desirable. The seam-welds are created by high frequency induction (HFI) and then normalised. Four different weld placements and processing types result from the manufacturing. The weld can be on the face or in the corner of the section, and the internal weld bead can be either trimmed or untrimmed. The outside weld bead is always removed. The placement of the weld may be a significant factor in any difference in the observed fatigue life.
As the welds can be at the corner, non-standard tests will be required to evaluate the fatigue life of the samples as the tubes are likely to be in bending and torsion for much of their life [2,3].

Initial Findings. The weld can be clearly seen and easily identified despite the normalisation process. Pearlite-Ferrite banding through the material that is characteristic of high manganese steels [4] is seen to spread at the weld to follow the flow of material in the weld area (Fig. 1). The ghost of the heat affected zone (HAZ) is also visible by eye.
The sample with the weld bead untrimmed (Fig. 2) shows stress concentration features on either side of the weld bead which would indicate a potentially lower fatigue life. Previous testing however suggests that this may not be the case.

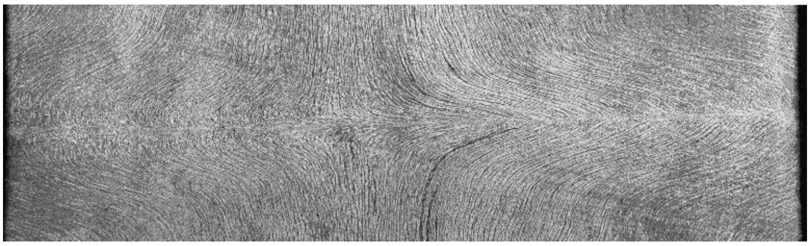

Figure 1: Microscope image of the grain patterns in the weld, weld bead trimmed.

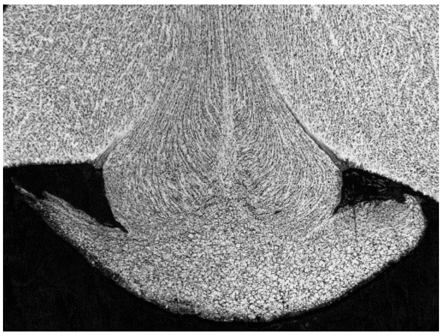

Figure 2: Microscope image of the grain pattern and features at the corner weld, untrimmed

Further Testing. The material characteristics of the parent steel were determined as well as those of the weld area to determine whether there were any differences between the two. These include the Young's Modulus, and hardness values across the weld. These were then compared to the specification for the steel. The properties were used to describe the material in a finite element model. Further simulations will be completed to determine the fatigue characteristics of the RHS as a whole. EBSD and EDX has been conducted to give a more detailed grain characterisation. It has shown a clear difference in the grain structures of the parent material and that near the features in the weld. The results of these tests were compared to the literature and the expected distribution of elements in the material.

Conclusion

The welds produced in the HFI process can still be seen after normalisation with the flow of metal visible in the Pearlite-Ferrite banding. The untrimmed welds show stress concentration features at the weld-bead between the parent and welded area which is likely to reduce the fatigue life of the tube and so trimming the internal weld bead may be a good way to reduce early failure. Fatigue tests will be used to update the finite element model which will in turn aid in prediction of the fatigue life of full-scale tube sections.

References

[1] British Standards Institution: *BS EN 10210-1: Hot finished structural hollow sections of non-alloy and fine grain steels — Part 1: Technical delivery conditions,* London, BSI; (2006).

[2] H. Achtelik, M. Kurek, and A. Kurek: *Non-standard fatigue stands for material testing under bending and torsion loadings,* Proc West Mark Ed Assoc Conf, Vol. 2029 (2018), p. 20005.

[3] A. Kešner, R. Chotěborský, M. Linda, M. Hromasová, E. Katinas, and H. Sutanto: *Stress distribution on a soil tillage machine frame segment with a chisel shank simulated using discrete element and finite element methods and validate by experiment*, Biosyst Eng, Vol. 209, (2021), p. 125–138.

[4] H. Bhadeshia: *Interpretation of the microstructure of steels*, (2008), https://www.phase-trans.msm.cam.ac.uk/2008/Steel_Microstructure/SM.html (accessed Feb. 19, 2023)