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Effect of Burr Grinding on the Fatigue Strength of Angled Welded Connections

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1 Introduction

Fatigue strengths of the most common welded connections are generally low compared with those of equivalent unwelded components. In the majority of cases, the weld toe is the most likely site of crack initiation. Standard yard procedures for improving fatigue life, such as weld toe grinding, re-melting and peening are reasonably cheap and provide benefits, delaying crack initiation.

The effect of grinding on fatigue life has been studied by a number of investigators who have primarily considered cruciform joints with normal attachments. In the shipbuilding industry, however, angled connections such as those forming the hopper knuckles and bulkhead lower and upper stools need to be considered. To establish the effect of weld grinding on the fatigue strength of these joints, transverse fillet welded specimens with inclined attachments were tested under constant amplitude cyclic loading. The experimental work was carried out for Lloyd's Register by the Krylov Institute.

2 Specimens and experimental set-up

Two specimens having normal attachments and dressed welds were tested under static load to failure.

Four sets of transverse fillet welded specimens were tested under constant amplitude cyclic loading as follows:

1. Ten specimens with inclined attachments in as-welded condition.
2. Nine specimens with inclined attachments and dressed welds.
3. Three specimens with normal attachments in as-welded condition
4. Three specimens with normal attachments and dressed welds.

Figure 1 show specimens with inclined attachments. These were manufactured from Grade A steel. Rotary burr tools of specified radii were used to perform weld dressing.

The tests took place under laboratory conditions at room temperature. The experimental set-up for the specimen with normal attachments is shown in Figure 2.

3 Fatigue test results

The fatigue tests were conducted under constant amplitude cyclic loading on a multi-purpose hydraulic testing machine. The applied load ratio was equal to 0.1. The loading frequency was 5 Hz.

Crack initiation in specimens was from the weld toe. Figure 3 shows a failed specimen with inclined attachments.

The nominal S-N data obtained for the specimens with inclined and normal attachments is presented in Figure 4 together with existing data for joints with normal attachments and the mean FAT80 S-N curve produced by The Welding Institute (TWI) [1] for specimens in the as-welded condition.

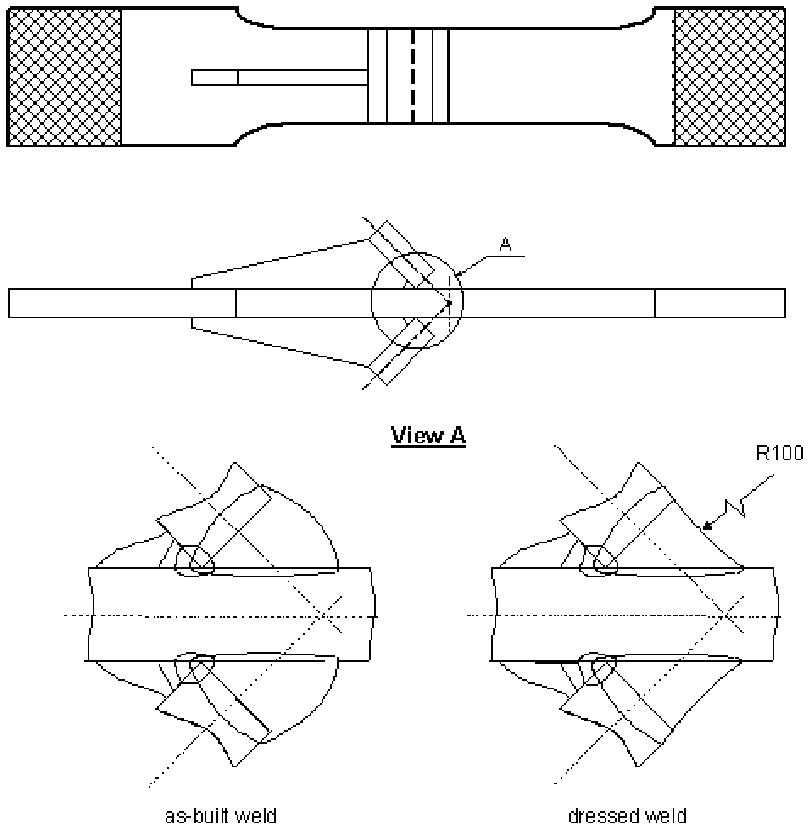

Figure 1: Specimen with inclined attachment in as-welded and dressed conditions

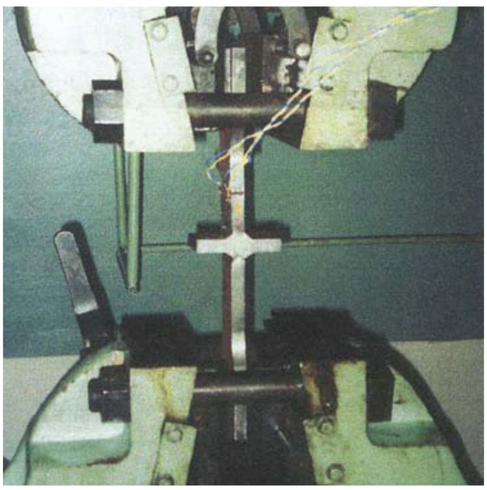

Figure 2: Experimental set-up for specimen with normal attachment

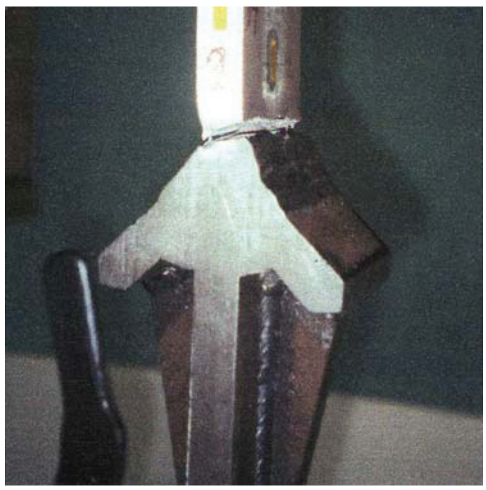

Figure 3: Failed specimen with inclined attachment in as-welded condition

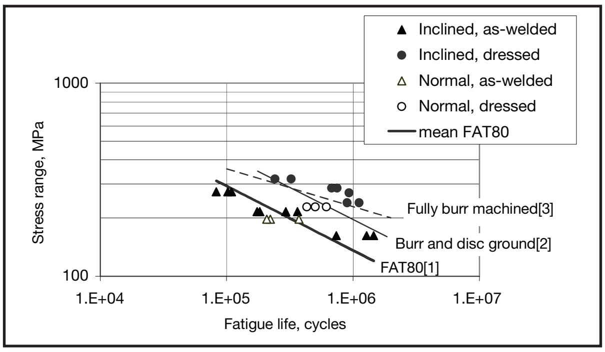

Figure 4: Fatigue test results

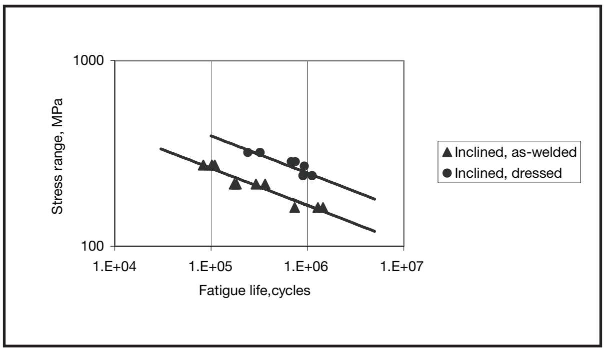

Figure 5: S-N curves for specimens with inclined attachments

The nominal S-N data for cases with inclined attachments was analysed assuming a linear S-N curve on a log-log scale as follows:

$$\log N = \log A - m \bullet \log \Delta S, \quad (1)$$

where parameters A and m are determined from experimental data. It was found that for both the as-welded and dressed conditions, the parameter *m* was close to 5. Assuming *m*=5.0, parameter A was calculated to be $1.265 \bullet 10^{17}$ for the as-welded specimens and $9.39 \bullet 10^{17}$ for the dressed specimens. These S-N curves are shown in Figure 5 together with the experimental points.

Using expression (1) and the above parameters, the ratio between stress ranges for the as-welded and dressed conditions can be expressed as:

$$\frac{\Delta S_{dressed}}{\Delta S_{as\text{-}welded}} = \left(\frac{A_{as\text{-}welded}}{A_{dressed}} \right)^{-1/5} = 1.5$$

This indicates that a significant reduction in stress concentration can be achieved with weld treatment such as full burr grinding.

It was recommended in [2] that the allowable fatigue design stress can be increased by 30% for burr and disc ground joints with normal attachment. This means that the stress concentration factor at the weld toe is reduced by a factor of 1.3 due to weld dressing. This is equivalent to increasing the design life by a factor of 2.

In this study, a reduction factor of 1.5 is obtained for specimens with inclined attachments. However, the quality of the weld treatment in the shipyard may not be as good as that performed in the laboratory, and some allowance needs to be made for this possibility.

Therefore, it is proposed to adopt the recommended factor of 2 increase in design fatigue life for both angled and cruciform transverse fillet welded joints if burr grinding is used.

4 Conclusions

Full burr grinding of the weld toe is found to be an effective way of improving the fatigue strength of angled transverse fillet welded joints.

Through this process, a two-fold increase in the design fatigue life can be achieved.

5 References

1. Fatigue Design of Welded Joints and Components. Recommendations of IIW Joint Working Group XIII-XV, International Institute of Welding, 1996
2. G S BOOTH, Improving the Fatigue Strength of Welded Joints by Grinding Techniques and Benefits. The Welding Institute, 1985
3. S MANTEGHI, Methods of Fatigue Life Improvement for Welded Joints in Medium and High Strength Steels. *Research Report, The Welding Institute, June 1998*