The Effects of Friction Stir Welding on the Microstructure and Mechanical Properties of Flash Bainite

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Research Objective

Evaluate friction stir welding's ability to maintain the mechanical and microstructural properties of Flash® Bainite 4130 Chromium-Molybdenum steel.

Introduction

4130 Chromium Molybdenum Steel:

- Low alloy (0.30% C, 0.8-1.1% Cr, 0.15-0.25%Mo)
- Light weight
- Fast and efficient manufacturing ("Flash")
- Extreme strength (80% Martensite)
- Ductile (20% Bainite)

Friction Stir Welding

- Can maintain mechanical and microstructural characteristics of metals joined
- Refines grain size and structure of Nugget Zone

Flash Bainite steel is a steel that is specially manufactured by rapidly heating to 1100°C in approximately 3 seconds, and rapidly quenched back to room temperature in the same amount of time. This allows for a phase structure of Martensite, and Bainite to form yielding an extremely strong and ductile steel. Where friction stir welding comes into play is that other welding processes melt the metal, or other metals that cause the grain structure to change and change the mechanical properties of the metal. By using friction stir welding on Flash Bainite it would allow for welds to maintain engineered properties of the steel and potentially increase the strength of the nugget zone.

Procedure

Weld Plan

	Axial Load	RPM	IPM	Condition (Weld Rank)
FB1	3500	200	2	2
FB2	2500	200	2	1
FB3	2500	200	5	Aborted
FB4	4000-5500	200	5	3
FB5	6500	200	7	4

Table 1: Table of weld parameters and weld quality.

Metallography

- Analysis of Nugget, Heat Affected Zone (HAZ), and edges of welds microscopy was made to determine which weld was ideal for tensile tests.

Micro-Hardness

- Vickers Micro-Hardness test was performed on the cross-sectional area of each weld to determine changes in mechanical properties due to Friction Stir Welding.

Figure 1: Finished Welds Samples 1, 2, 3, 4, 5 respectfully.

Figure 2: Sample FB1

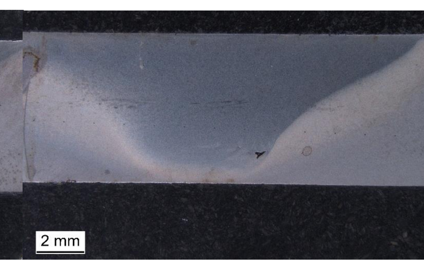

Figure 3: Sample FB2

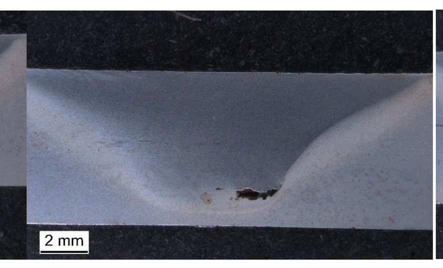

Figure 3: Sample FB4

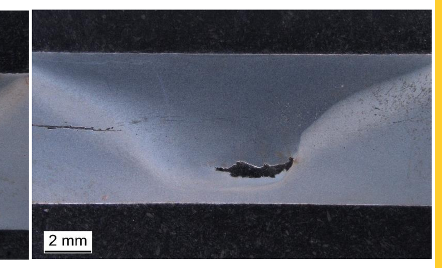

Figure 4: Sample FB5

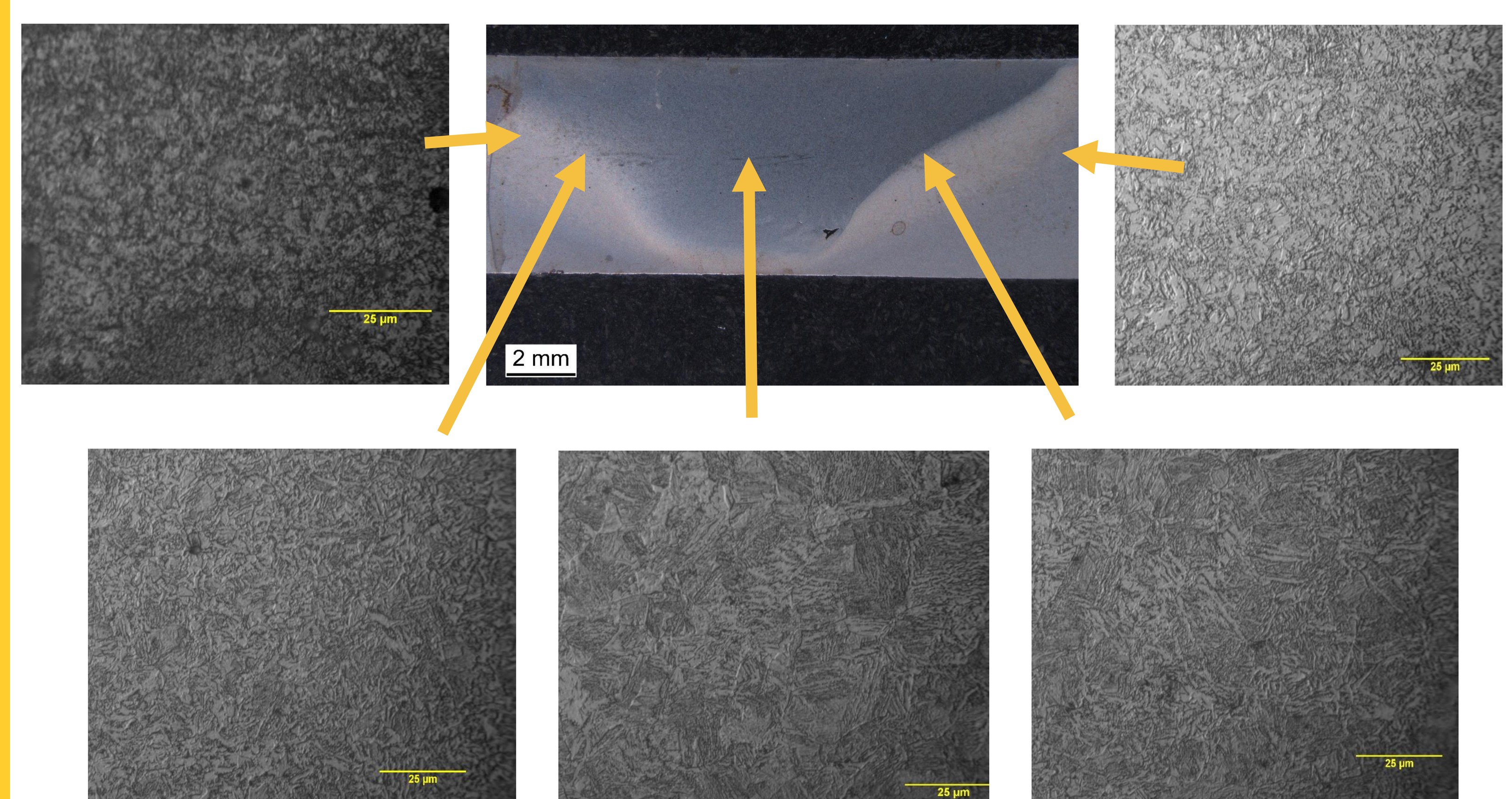

Figure 6: Enlarged FB2 and metallography across the cross section.

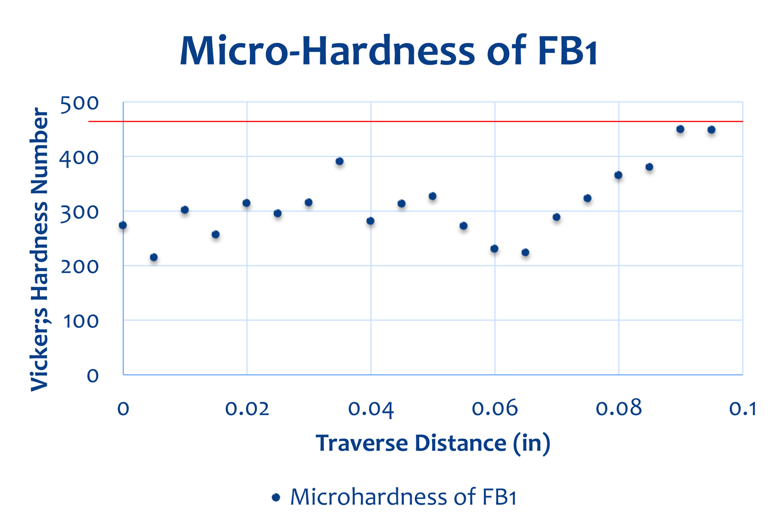

Figure 7: Micro-Hardness of the weld zone of FB1.

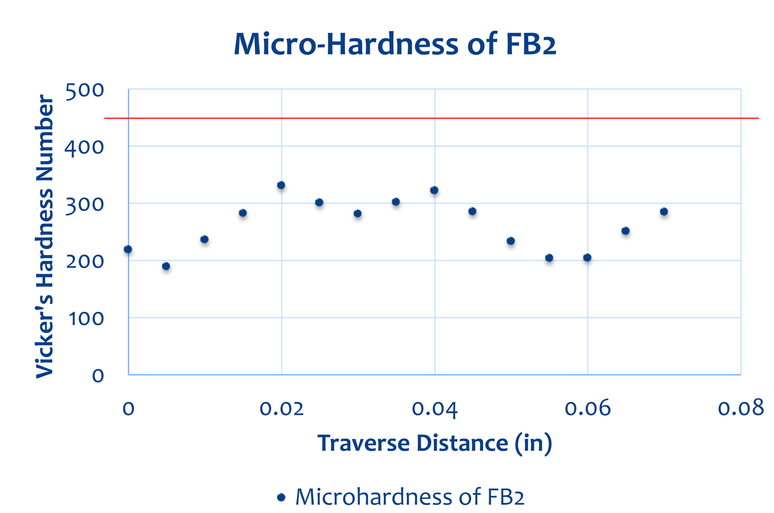

Figure 8: Micro-Hardness of the weld zone of FB2.

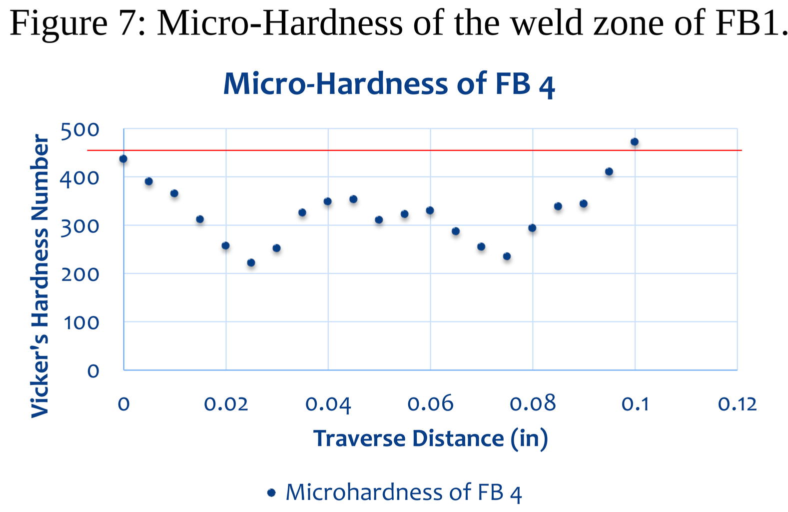

Figure 9: Micro-Hardness of the weld zone of FB4.

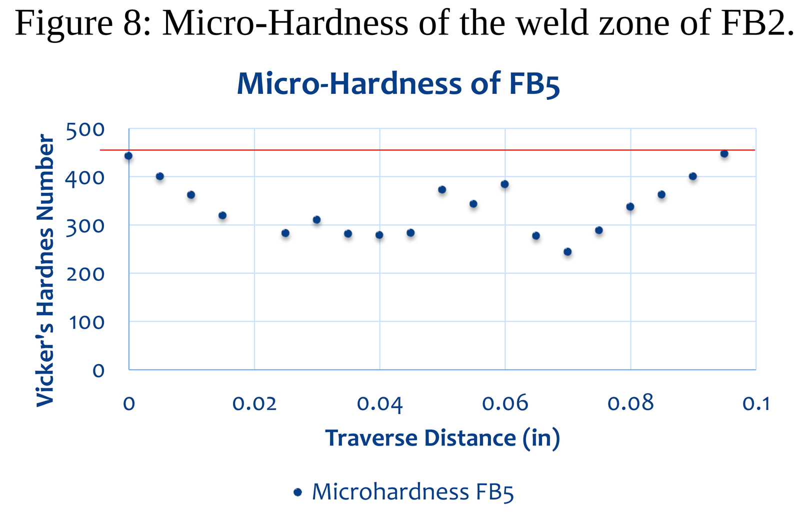

Figure 10: Micro-Hardness of the weld zone of FB5.

Red line indicates hardness of parent metal.

Results

Welding

- All welds showed worm hole defects
- Sample FB2 had the smallest defect
- Sample FB2 was chosen as the test weld for future tensile testing

Metallography

- Samples FB1 and FB2 had the finest microstructure within the Nugget Zone, Heat Affected Zone (HAZ), and least affected in the area's outside of the weld.
- Bainite and Martensite mixture maintained.
  - Some differences in the Heat Affected Zone
  - Microstructure is smaller in nugget

Micro-Hardness

- Hardness increased as measurements were made from the edges towards the center and towards the far edge.
- At the center of the nugget zone hardness dropped indicating the possibility of the samples maintaining their ductility

Future Work

Tensile Tests

Tensile testing will be done to measure the amount of stress that can be applied to the parent material as a base strength and ductility, and then tensile testing will be done in accordance to a weld being made down the center of 2 tensile dog-bones and compare the differences in strength and ductility.

Acknowledgements

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References

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