The Efficacy of Friction Stir Welding in High Strength Steel Production

Timothy Fountain

(South Dakota School of Mines & Technology)

Faculty Advisors: Dr. Bharat Jasthi, Dr. Michael West

Introduction

- Friction stir welding (FSW) is a solid state welding process in which a rotating bit generates heat and stirs material together
- Offers significantly better mechanical properties than traditional fusion methods
- Very beneficial in high strength applications where welded material must maintain pre-weld properties
- Concerns about slow travel speed and excessive tool wear exist

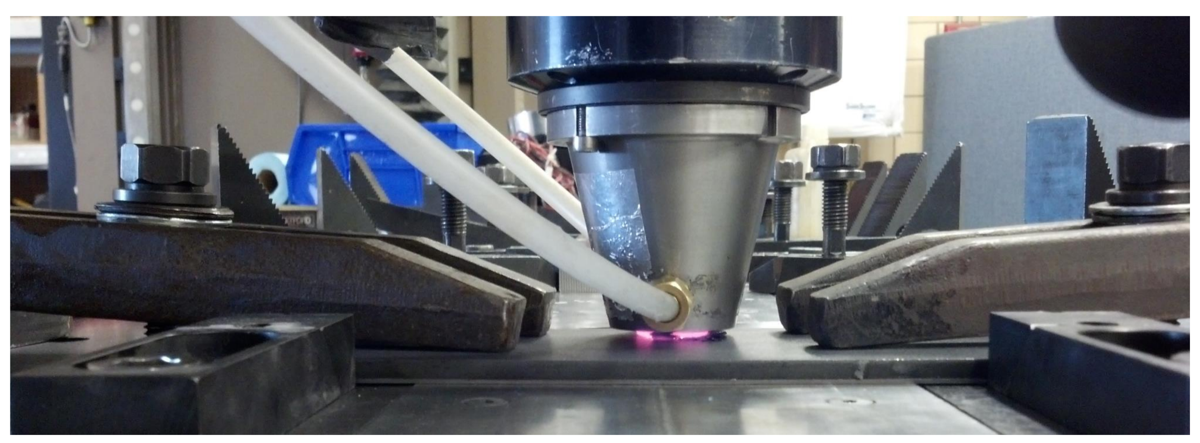

Figure 1: Friction stir welding of high strength steel

Project Goals

- Maximize weld parameter efficiency while maintaining mechanical properties of parent material
- Explore tools that are both able to withstand rigors of production and are cost effective
- Compare results with fusion welding methods

Procedure

- Tools chosen
- Weld parameters developed
- Microstructural characterization
- Mechanical property evaluation

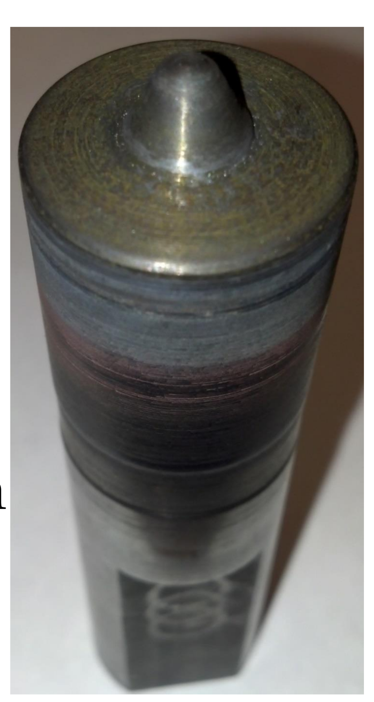

Figure 2: Tungsten rhenium hafnium carbide tool

Parameter Development & Microstructural Characterization

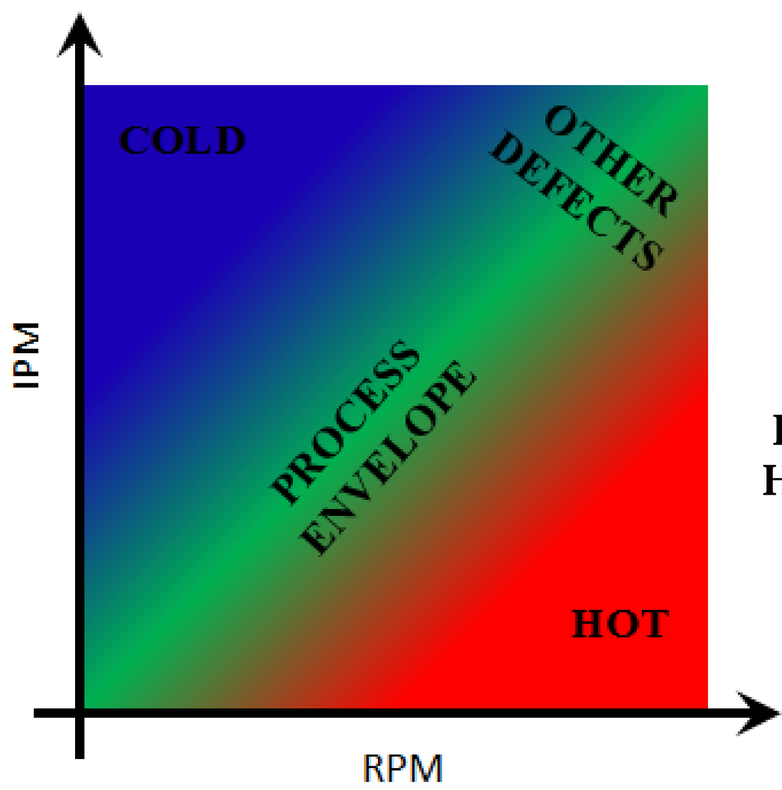

Figure 3: Graphical representation of balancing weld parameters

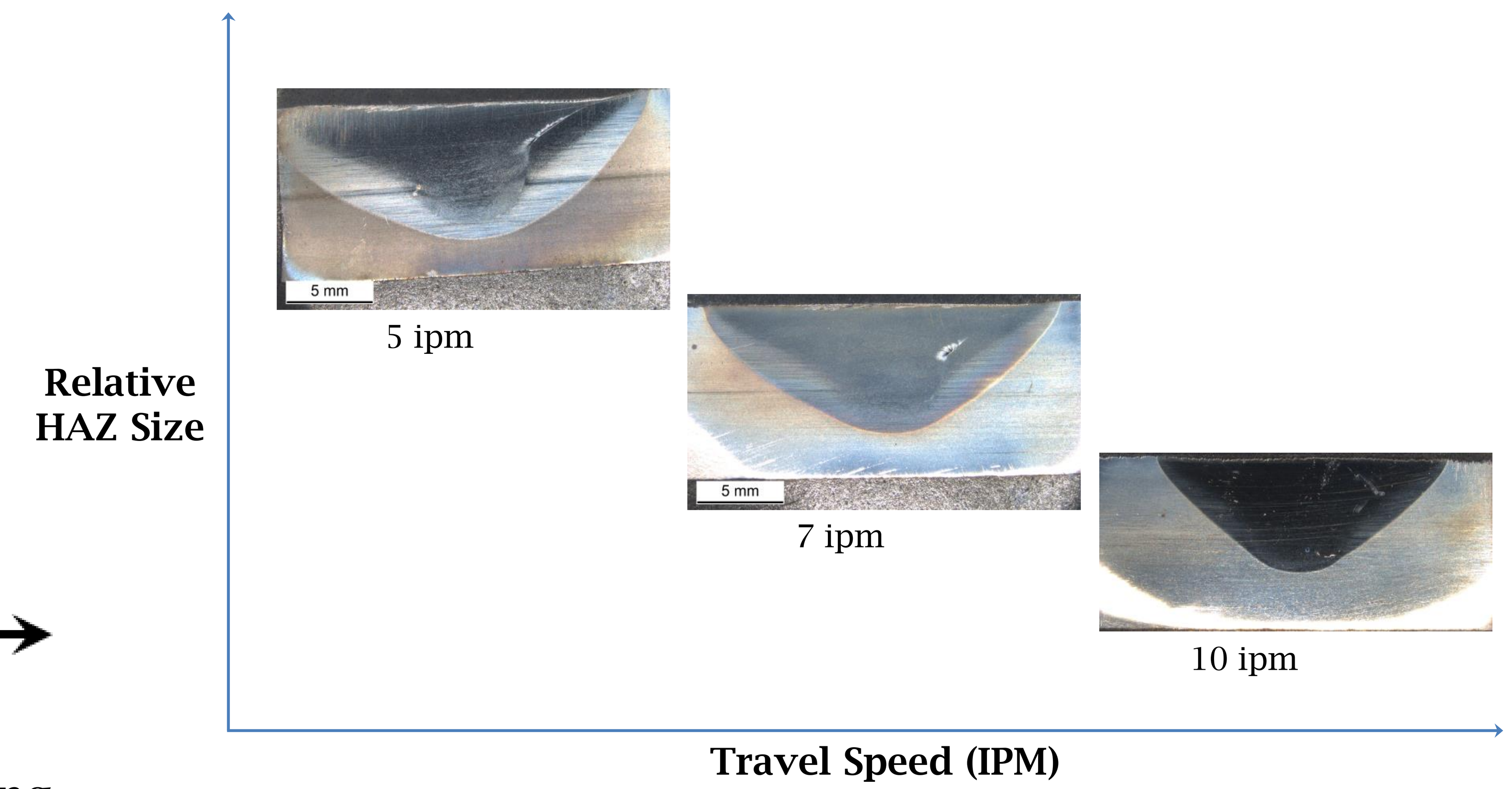

Figure 4: Decreasing HAZ size with lower heat input

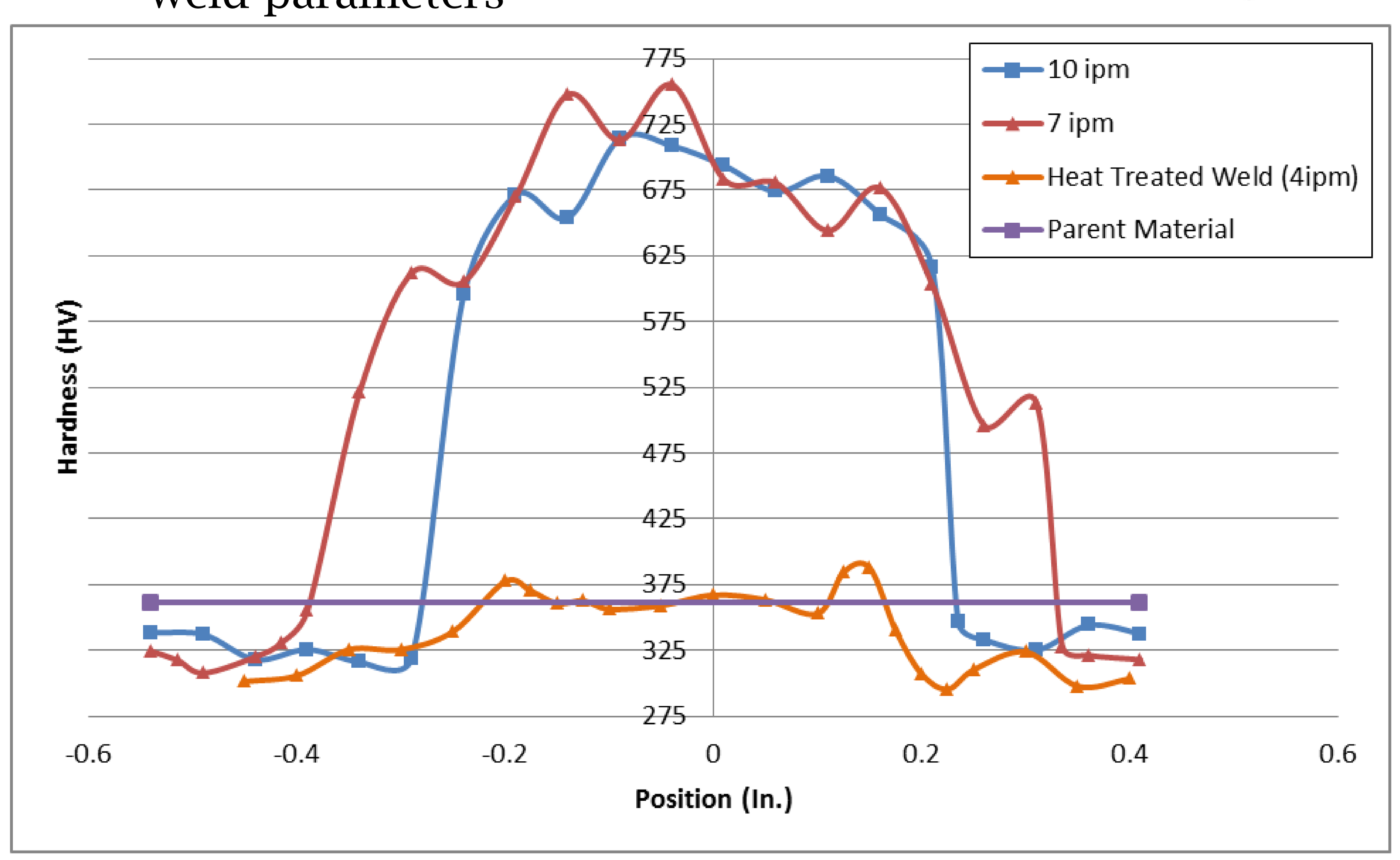

Figure 5: Microhardness traverses of different weld parameters

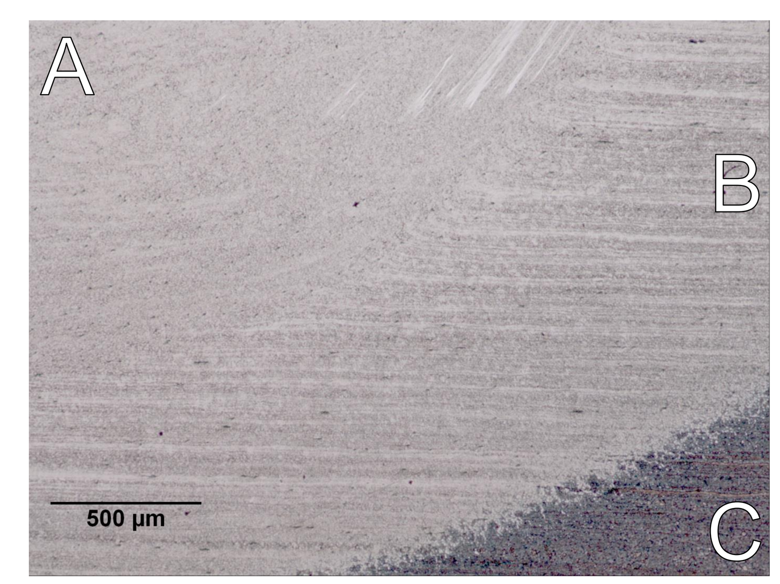

Figure 6: Layers of weld material at 7ipm.
A: Weld nugget
B: TMAZ/HAZ
C: Parent Material

Tensile Testing

Material Condition	YS (ksi)	UTS (ksi)	Elongation (%)
Parent Material (as rolled)	108 ± 0.2	148 ± 1.4	6.5 ± 0.7
Parent Material (thick, heat treated)	121 ± 0.4	148 ± 0.8	11.7 ± 0.8
Parent Material (thin, heat treated)	123 ± 0.4	143 ± 1	12.2 ± 1
Transverse Weld (as welded)	123 ± 1.6	152 ± 10.5	3.2 ± 0
Transverse Weld (heat treated)	121 ± 1.4	147 ± 1.8	10.6 ± 1.4
Longitudinal Weld (as welded)	128 ± 0.8	216 ± 10.7	N/A
Longitudinal Weld (heat treated)	145 ± 7.9	155 ± 4.4	10.4 ± 1.2

Table 1: Results of tensile testing of parent material and FSW material.

Discussion

- Higher heat input creates a larger HAZ region
- Martensitic transformation leads to increased hardness and decreased ductility in weld nugget
- Post weld heat treatment returns hardness and ductility to acceptable levels
- Tensile properties are superior to fusion welding processes

Conclusions

- Mechanical properties obtained from FSW material is superior to fusion welding methods
- Efficiency in a steel production setting still questionable
- Tool wear so far a non issue, but more data is needed to determine production feasibility

Future Work

- Sub critical welding
- Fatigue testing
- Quantitative tool wear studies

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