

# Friction Stir Processing of Grey Cast Iron

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## Research Objectives

- Design parameters to properly FSW Grey Cast Iron
- Analyze defects in grey cast iron welds
- Determine properties of FSW cast iron

## Introduction

- Previous work using preheating induction coil was unsuccessful
- Graphite flakes act as lubricant and make it difficult to obtain enough frictional heat to FSW cast iron alone
- Steel cover plate is used to help better attain frictional heat

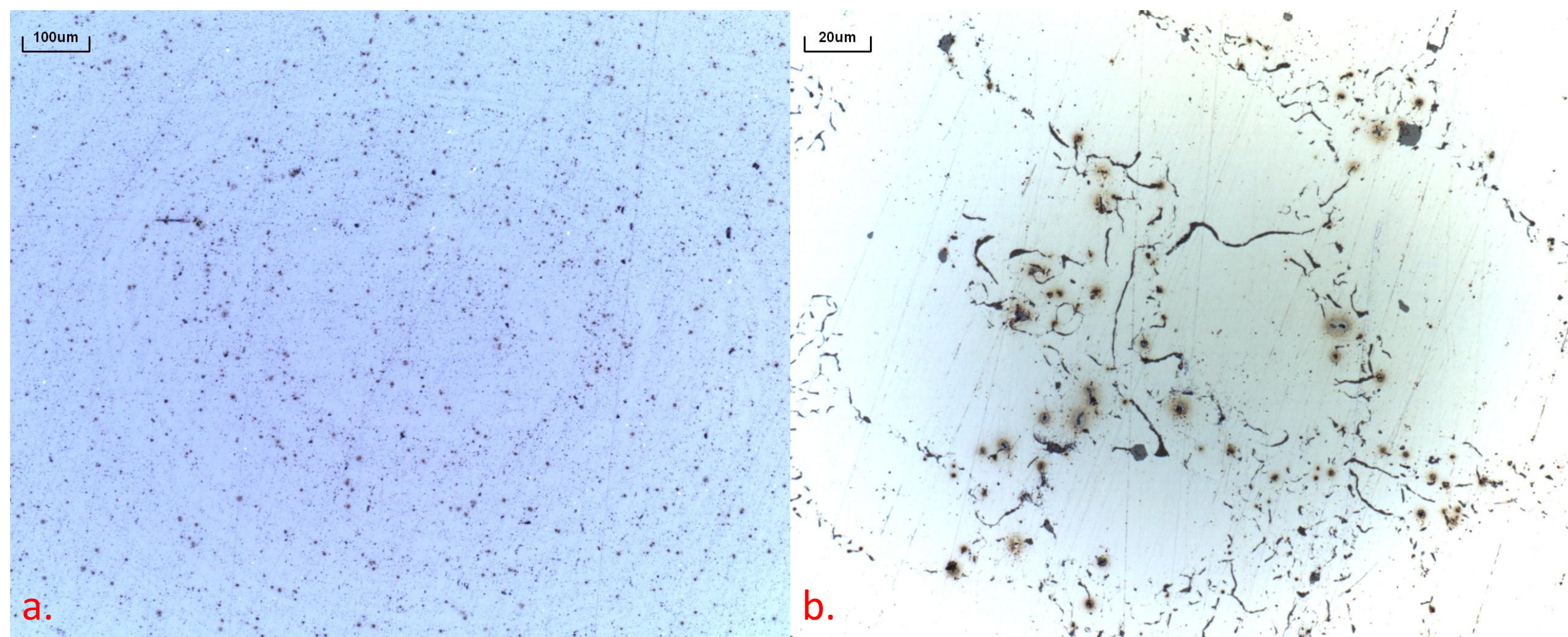


Fig. 1: (a.) graphite in center of weld (b.) graphite in parent material

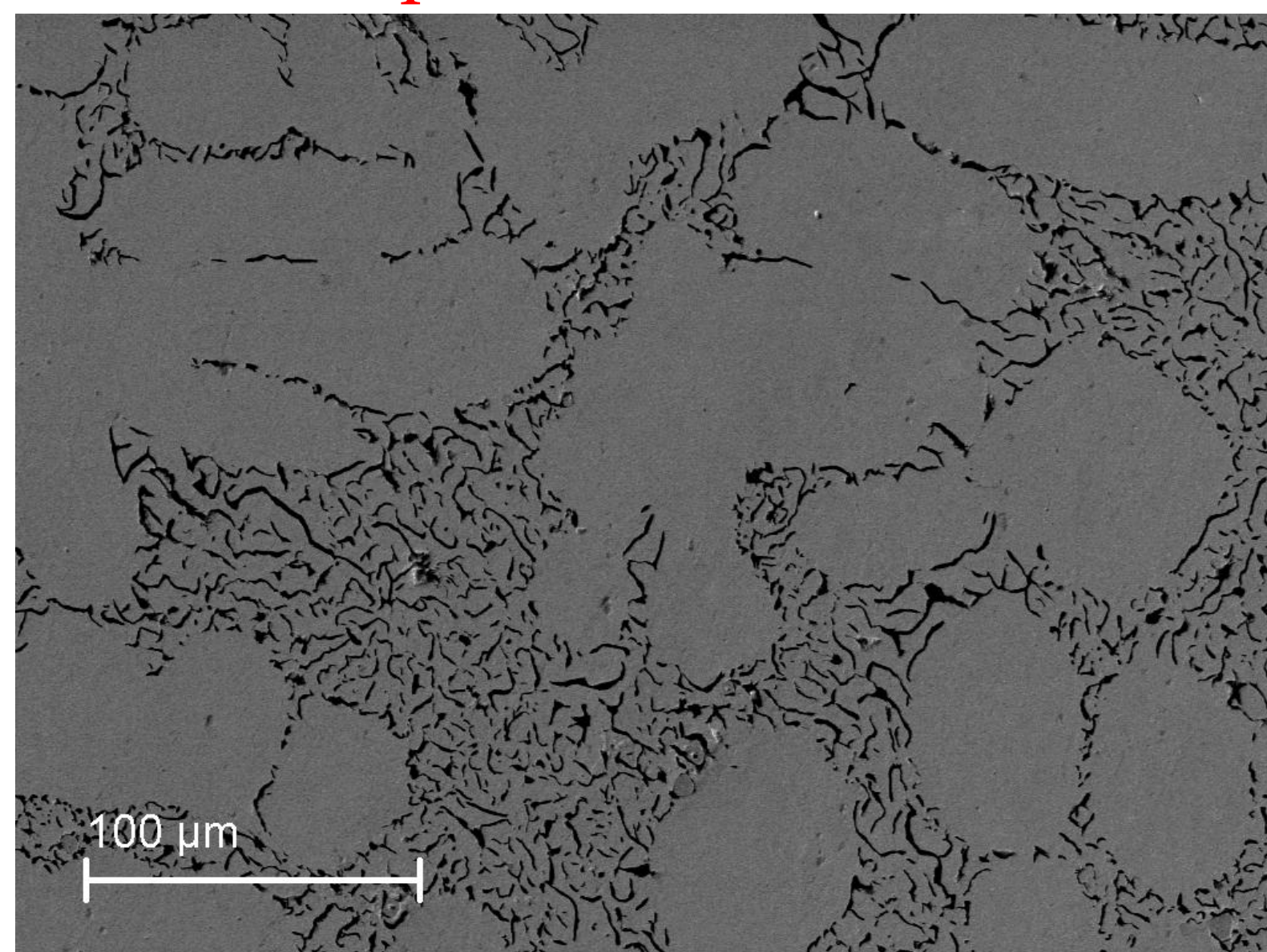


Fig. 2: SEM image of grade 40 grey cast iron parent material.

## Procedures

- **Preparation of parent tensile samples**
  - Mill down cast iron plate from 0.25" to 0.190"
  - Separate sample into four specimens using band saw; length of 5.8825" and width of 0.51"
  - Specimens then put into tensile jig and machined to ASTM tensile test specifications.
- **Preparation of FSW tensile samples out of previous weld**
  - Machine off steel cover sheet and machine 0.26" from back side.
  - Cut samples into two specimens using band saw, with length of 5.6875" and width of 0.493"
  - Specimens put into tensile jig and machined to ASTM standards.
- **Use MTS machine to do tensile tests**
  - Compare both tensile data
- **Take metallographic samples**
- **Weld (Fig 3.)**
  - MTS ISTIR 10 to weld cast iron at 3200 lbf forge weld at 1000 RPM, 0.25 IPM
  - Use CS4 PCBN pin tool
  - Clean cast iron and steel plates
  - Heat up steel anvil to 150°C
  - Clamp steel cover plate on top of cast iron plate



Fig. 3: (a.) Welding of cast iron with steel cover plate (b.) finished cast iron weld.

## Future Work

- Eliminate retreating side in welds exceeding 3300 lbs forge welded by welding two side by side welds in opposite directions
- Create dogbone samples of processed zone in order to discover tensile properties of weld area

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## Results

- At 3300 lbf the weld broke far before expected during tensile testing (Fig. 4)

	Parent			FSW		Units
	2	3	4	1	2	
Ultimate Strength	49.6	49.8	47.6	2.72	7.24	ksi
Percent Elongation	0.01274	0.0098	0.01078	0.00832	0.00489	in/in

Fig. 4: chart showing peak stress of 3 parent samples and 2 FSW tensile samples

- All tensile samples fractured on retreating side
- SEM and EDS show large amounts of graphite on fracture surface (Fig. 5)

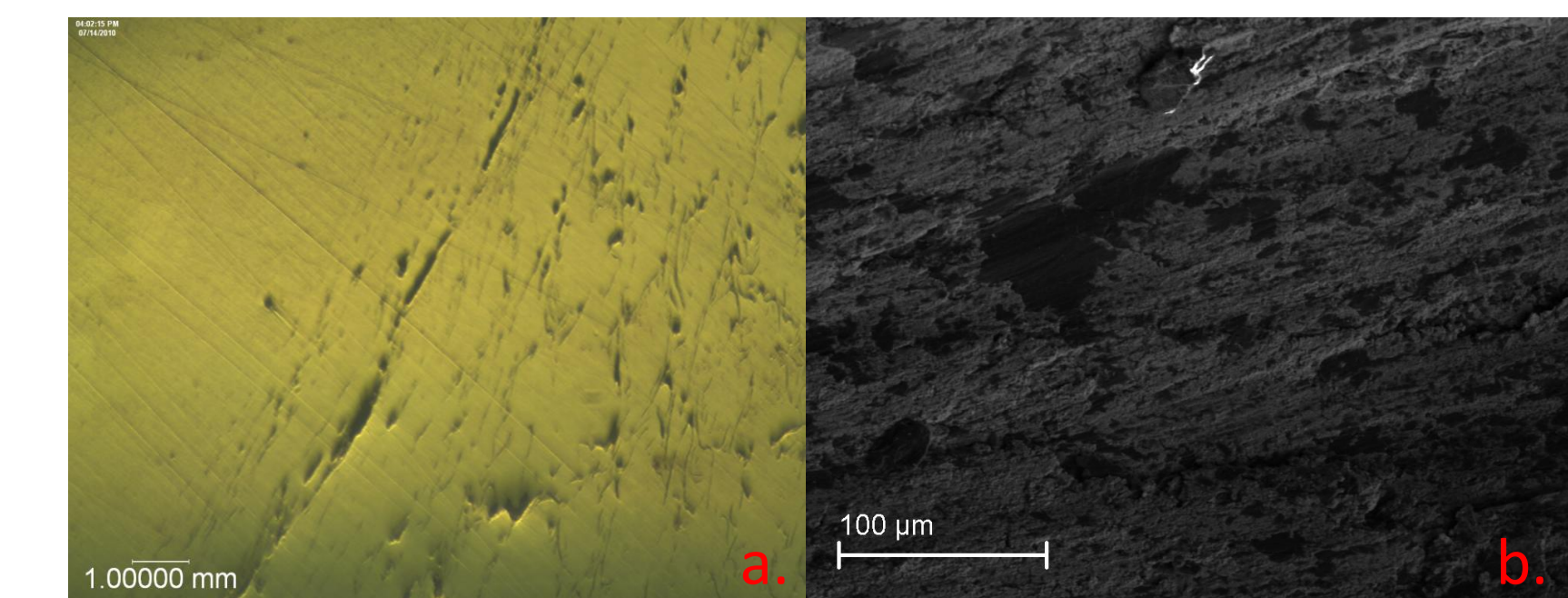


Fig. 5: (a.) graphite segregation in TMAZ (b.) fracture surface covered in graphite spots

- Extremely fine graphite flakes in center of weld
- Below 3300 lbf forge force, nugget-parent material interface is quite poor
- Good consolidation of graphite using steel cover plate
- Graphite in TMAZ appears to align

## Conclusion

- Welds should be made with forge forces at 3200 lbf or above
- Steel cover plate does consolidate graphite and allow for frictional heat.
- Plates need to be clamped in a specific manner in order to avoid bowing of steel panel