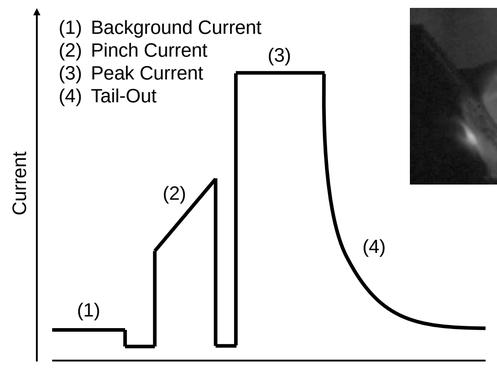
Waveform Controlled Gas Metal Arc Welding of Corrosion Resistant Alloys Without Back-Purging

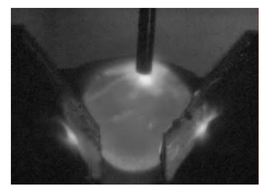
Jeremy McNicol, Graduate Student
Carolin Fink, Faculty Advisor
Department of Materials Science and Engineering, The Ohio State University

MANUFACTURING & MATERIALS JOINING INNOVATION CENTER

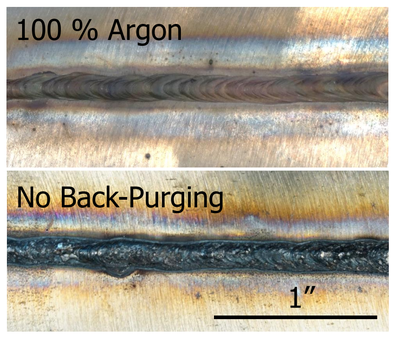
Background & Motivation

- Backing gas is typically used in open-gap root welding of corrosion resistant alloys, such as austenitic stainless steels to protect from atmospheric contamination, oxidation, and loss of alloying element.
- Back-purging can be costly or impractical due to access restrictions, personnel safety, or economic factors.
- Efforts using waveform controlled gas metal arc welding (GMAW) to eliminate the need for back-purging have been reported to achieve code acceptable welds with excellent corrosion resistance.
- However, results in the literature are sparse and presented somewhat superficial, hindering further application of the technology.





Waveform parameters in current controlled dip transfer technique and 304 SS weld with and without backing gas (this work).



Objectives

Explore the use of waveform controlled GMAW processes for open-gap root welding of austenitic stainless steels without backing gas.

(1) How can these processes be used to eliminate the need for back-purging in corrosive applications?
(2) Which parametric factors are important to achieve high quality welds with acceptable corrosion performance?

Understand relations between welding process, microstructure, and corrosion performance.

Approach

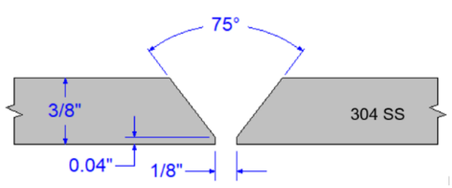
Task 1: Process and Material Selection
- Modified short arc process (root pass) and GMAW-P (hot pass)
- 308L/308LSi filler metal on 304L base metal

Task 2: Baseline Welds with Back-Purging
- Reference data for achievable weld quality and performance
- (Cryogenic) calorimetry to determine actual heat input

Task 3: Welding with No Backing Gas
- Effect of different shielding gas mixtures, gas flow rate and root gap on degree of discoloration and surface oxidation
- Effect of high Silicon content filler metals (308LSi, 316LSi) on backside wetting and deoxidation
- Analysis utilizes LOM, SEM/EDS, XPS, AES

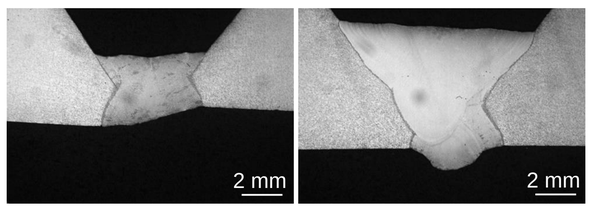
Task 4: Corrosion and Mechanical Testing
- Localized (Cyclic Potentiodynamic Polarization or ASTM G-61) and intergranular corrosion testing (Electrochemical Potential Reactivation or ASTM G-108)
- Mechanical testing (bends, tensile, hardness measurements)

Weld	Backing Gas	Wire
#1	None	ER308L
#2	None	ER308LSi
#3	Argon	ER308L
#4	Argon	ER308LSi
#5	95% Ar / 5% O_2	ER308L
#6	95% Ar / 5% O_2	ER308LSi

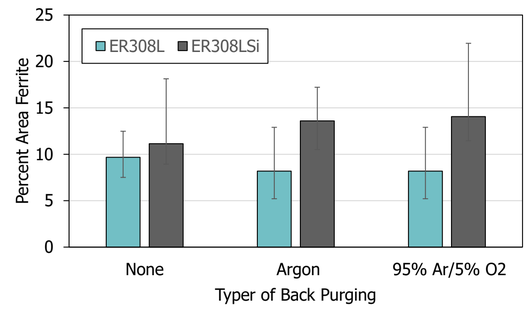


Initial test matrix and joint design on 304L base plates.

Results & Discussion

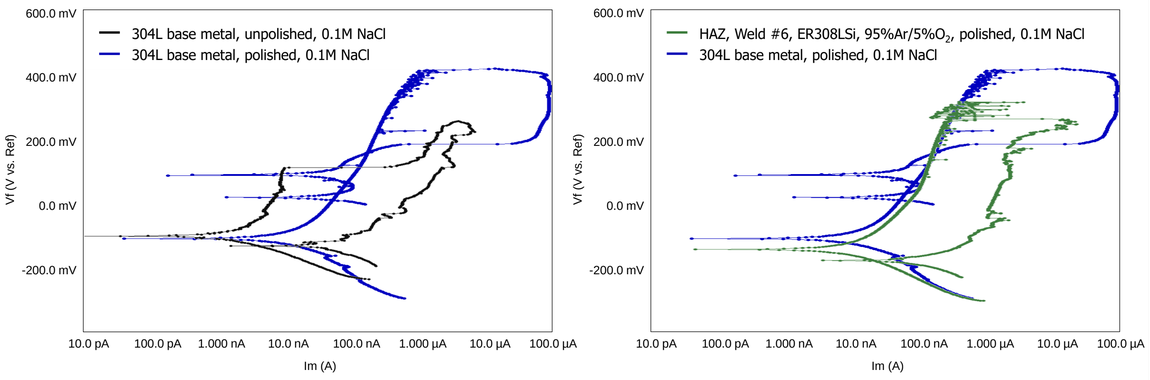


Cross-sections of ER308LSi welds (#2) with no back purging: root pass only (left), and root and additional hot pass (right).



Percent area ferrite in fusion zone of root pass welds with ER308L/ER308LSi.

Electrochemical corrosion testing using syringe cell setup to determine the effect of non-backing gas welding on localized corrosion in the heat-affected zone (HAZ) and root weld metal.



Cyclic polarization curves: 304L base metal unpolished to polished condition (left), and weld #6 HAZ region to base metal, both in polished condition (right).

Conclusions and Future Work

- Syringe cell setup and sample preparation for localized corrosion testing in HAZ and root weld metal was optimized.
- Polishing of backside weld surface yields more consistent polarization curves.
- Ongoing work on metallographic analysis (i.e. bead shape, dilution, HAZ microstructure, backside wetting) of welds.

Acknowledgements

This research is funded within the NSF IUCRC Ma²JIC center. Thank you to Lincoln Electric (Badri Narayanan, Mike Barrett), Shell (Jorge Penso), AO Smith (Bruce Krakauer), and EPRI (Steve McCracken) for their guidance and support.

"Center Proprietary"