Plasma Arc Cutting Experimental Setup & Analyses

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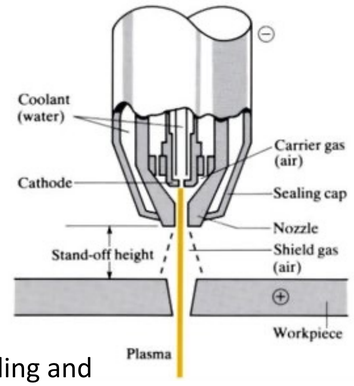
Hypertherm

Background

This senior project serves as an introduction to the NH IRC project partnership between Hypertherm and UNH.

Hypertherm reports that their clients experience poor adhesion to paint, poor weld quality, build up or resolidified materials, and unexpected corrosion of a plasma arc cut surface.

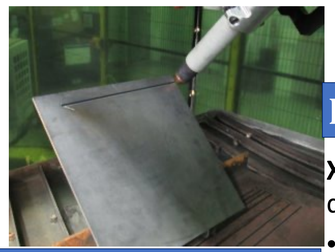


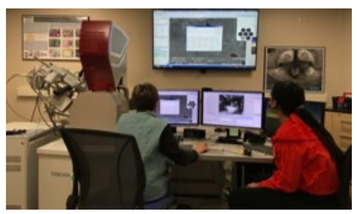
Hypertherm is interested in understanding and controlling the chemistry changes that occur at the plasma arc cut surface and hypothesize that torch orientation has major effects on nitrogen absorption levels and surface roughness in A36 steel.

Objectives

To design and implement an experimental setup for Plasma Arc Cutting (PAC) at the UNH John Olson Advanced Manufacturing Center using the PowerMax 125 Plasma Cutter and the KUKA robotic arm.

- Fixture design, building, and training on the KUKA robotic arm. The Olson Center is now fully equipped to handle automated PAC.
- Analyze material changes in the cut surface: Using X-Ray Photoelectron Spectroscopy, optical microscopy, and Electron backscatter diffraction to gather preliminary result characterizations.





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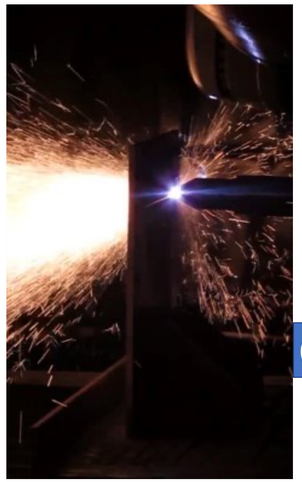
Thank you!

Fixture Design and Test Performed

- Intended to allow the robotic arm to move around the workpiece and perform cuts in any direction
- Needed to be covered to protect the surrounding area from flying sparks that fly during the cuts
- Designed to hold a workpiece of at least 100lbs.
- Fume hood was installed to keep the fumes away from the work area



- Manual hand cutting was performed to help us figure out the optimal method to cut samples
- The robotic arm was used to cut uniform and consistent samples . Automated PAC precisely controls variables such as speed, orientation, current, and air pressure.

Results: Elemental Analysis

XPS: Even the base material has nitrogen present. Possibly due to diffusion in hot rolling process.

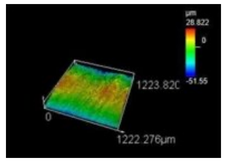
- High levels of carbon and oxygen, potentially tied to metal oxides, and other elements.
- Carbon and oxygen levels significantly decrease after etching. eV levels also shift, suggesting a change in chemical composition. Nitrogen levels slightly decrease.
- No significant trend with any results tied to torch orientations

SEM : no difference in the nitrogen content between the samples that were cut with the plasma and samples that were cut with the waterjet.

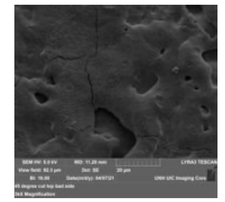
Results: Surface Roughness

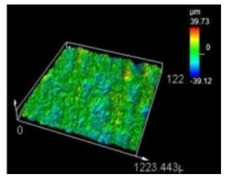
Olympus Confocal Microscope

- Results shows that the water jet has the lowest surface roughness value, while the 45-degree plasma cut surface has the highest roughness value.
- Water jet surface transition between high and deep area over short distances, while the plasma surfaces transition more smoothly
- From SEM, the surface appears cracked and porous (top right), possibly due to high heat exposure and rapid cooling. Cracks are not ideal in metals.

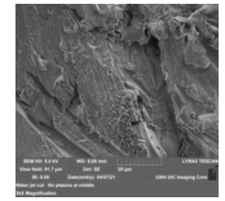


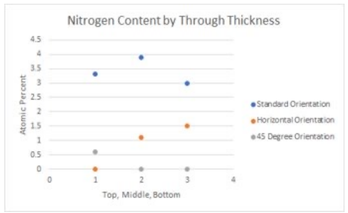
45 degrees plasma cut surface





Vertical water jet cut surface





Standard Orientation (Depth)		1st Scan (bottom)	2nd Scan (bottom)	3rd Scan (bottom)
N	Atomic conc. %	3	2	1.9
	Weight conc. %	2.6	0.7	0.6
O	Atomic conc. %	37.3	36.2	33.9
	Weight conc. %	36.8	14.2	12.2
C	Atomic conc. %	51	11.4	9.5
	Weight conc. %	37.8	3.4	2.6

Conclusion

- There is no apparent trend in nitrogen content and through thickness. Nitrogen seems to be tied to an organic matrix. There is not enough data to say whether surface chemistry is altered significantly by torch orientation.
- More analysis needs to be done to find trends in elemental composition and surface roughness.
- Heat Affected Zone (HAZ) can be determined by Focused Ion Beaming on SEM machining to get defined depth.
- For future, we will test for hardness, incorporate the water table with the fixture, and run more tests on XPS for elemental analysis.