# Automated Cartridge Changer for Hypertherm Plasma Cutting Torch

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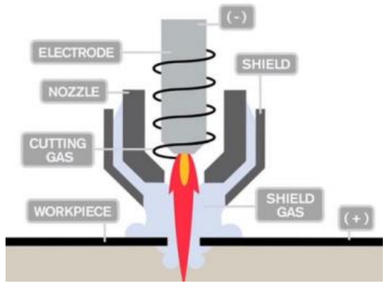
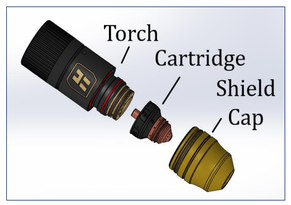
## Introduction

Hypertherm is a leader in plasma cutting technologies. The plasma cutting process is used as an alternative method to cut through metal surfaces within many industries.



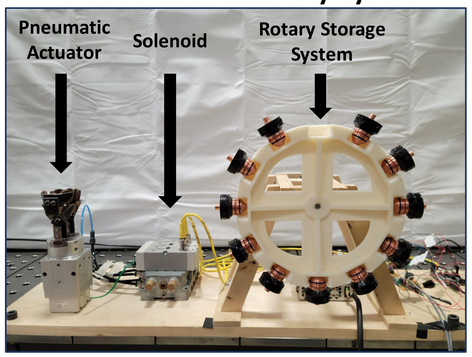

Hypertherm HPRXD torches are comprised of three components: The torch, cartridge, and shield cap.

- Hypertherm is interested in developing a system that can automatically change cartridges
- This system will be supplementary to their current HPRXD plasma cutting systems
- Total system should disassemble torch, change cartridge, and reassemble torch for immediate cutting




## System Setup

### Removal and Assembly System

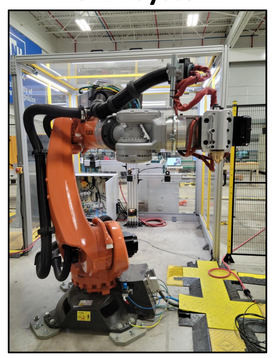



**Pneumatic Actuator:**
Shield cap removal/ assembly

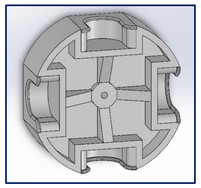
**Solenoid:**
Controls air flow for pneumatic actuator via electrical signals

**Rotary Storage System:**
Holding cartridges for future assemblies

### KUKA System

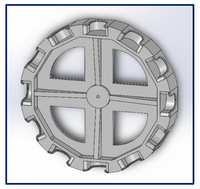


**Four-Slot Prototype**



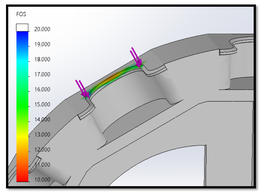
- A four-slot prototype was made for proof of concept
- Rotary design able to hold multiple types of cartridges
- Symmetrical for easy coding and weight distribution
- After SolidWorks testing and physical testing done a final design was made

**12-Slot Final Design**

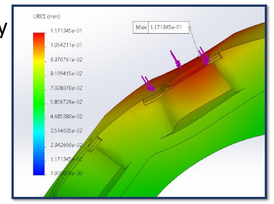


- Final design is a 12-slot rotary system
- Connected to a servo motor run by an Arduino

**FOS During Assembly**



**Displacement During Assembly**



The maximum cartridge removal and assembly forces were found using a strain gauge.

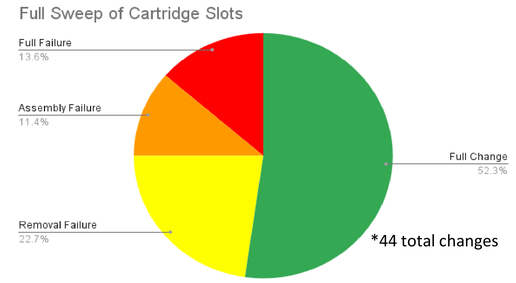
- Repeated force measurements (25 tests each)
- Maximum Removal force of 30N
- Maximum Assembly force of 60N (Worst Case)

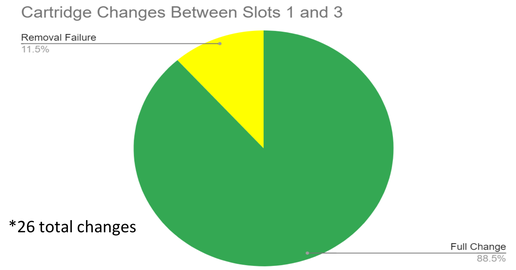
SolidWorks FEA was conducted under the worst-case assembly scenario.

- Maximum Von Mises stress of 1.864 MPa (Min. FOS of 11.8)
- Maximum deflection of 0.12mm

## Results

The main application for this system would be in a commercial environment where accuracy and efficiency are crucial. To measure the success of the system and to verify it would be beneficial, repeated testing was performed.




Average cartridge exchange time was found to be 55 seconds. Our two main sources of error occur because of misalignment of some storage slots when applying a new cartridge and the cartridge being removed along with shield cap upon shield cap removal.

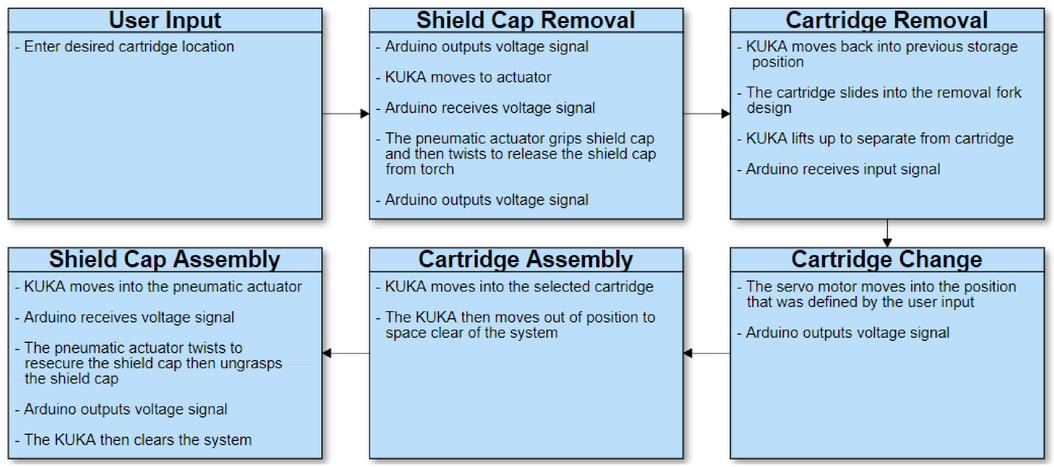
## Design Criteria

Our design must follow the following criteria:

- Design must be able to change cartridge without operator interaction
- Must work with current and future HPRXD models
- Must be able to withstand forces from KUKA robot arm
- Cartridge change time should be under a minute
- Cartridge holder should be able to accommodate 12 cartridges (3 Cartridge types: 60A, 130A, 260A)
- System must be controlled by a microcontroller

With the Design Criteria in mind, we decided to create a 12-slot rotary system controlled via an Arduino for the automatic cartridge changer.

## Automation Process




## Future Work

- Shield to encase storage system design
- Invest in higher resolution motor for better storage system location positioning
- Fully automated cartridge selection based on material specifications
- Track life of cartridges so system automatically changes them out
- RuBee/RFID technology to track cartridges

## Acknowledgements

The team would like to provide their sincerest thanks to Terence O'Neil and Brian Currier of Hypertherm, as well as Professor Brad Kinsey and Nathan Daigle for their help and guidance.