Hypertherm Plasma Torch Automatic Cartridge Changer

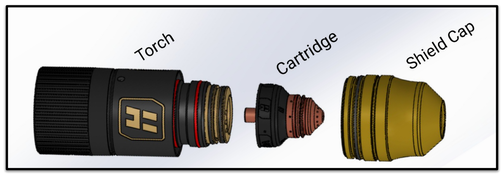
William Girard Tristan Herbert Isaac Mathewson
Jeremy Rescott Samuel Twombly
Mechanical Engineering, University of New Hampshire, Durham, NH

Introduction

- Replacement of used components for Hypertherm plasma cutters
- Three stages of automation including: shield cap unthreading/rethreading, used cartridge deinstallation, and new cartridge installation
- A new stationary Fork design created for cartridge install/deinstall
- Purchased a prebuilt actuator and designed grippers to remove and install the shield cap from torch
- Given the XPR 300 plasma cutter torch to test on
- Fully Automated Process

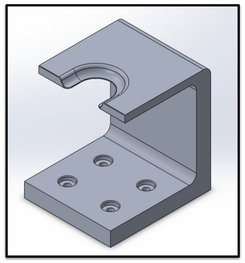
Design Considerations

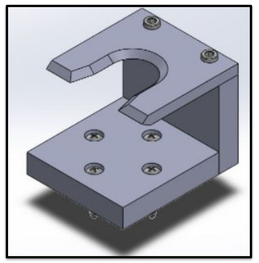
- Changed stationary fork design several times in order to decrease deflection & strength. This involved changing the design from three to five pieces
- Created rubber pads on grippers to increase friction between the grippers and shield cap
- Created stationary fork design to optimize production costs/material
- All designs were based off complexity, cost, speed, ease of manufacturing, safety and accuracy



Mounted Fork Cartridge Removal

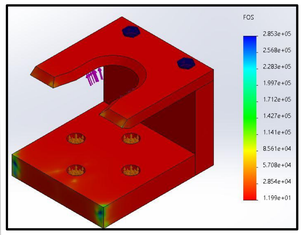
Fork Design Options



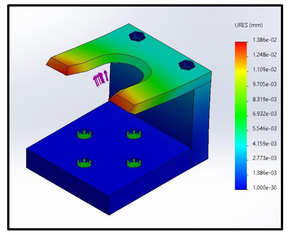


- Original 1-piece design
- Optimized 3-piece design
- 0.25” and 0.5” machined Aluminium

SolidWorks Simulations



Factor of Safety



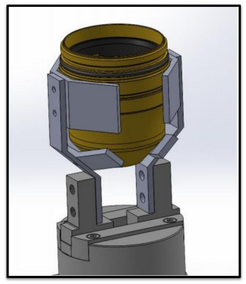
Deflection

- A force of 12.7 lbs was applied to the top plate
- Needed a minimum F.O.S. of 2
- Needed the deflection to be close to 0 mm

Gripping Fixture For Holding and Unscrewing Shield Cap

- Redesigned from first semester’s passive design
- Steel four finger gripping arms attached to a pneumatic actuator
- Actuator performs both gripping and rotating actions
- Pneumatics controlled manually
- Rough cut with riveted connection
- Tested with and without rubber padding
- Achieves the necessary 24 in-lb of torque and
- Rotates 180 degrees of the needed 90 degrees
- Applies 32 in-lb of gripping force
- Experienced misalignment during take off
- Hold and maintain cap location
- Tested and approved for 3D printing
- Holding the vertical and slanted portions of the cap

Initially Tested Grippers:



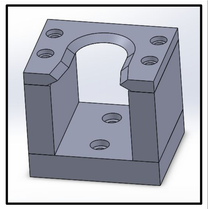
Initial Solidworks Gripper Modeling

Prototype Metal Gripper

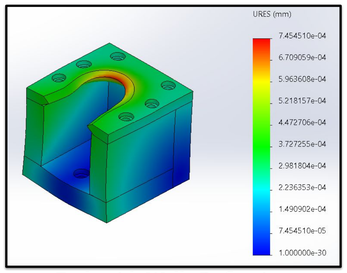
Redesigns

Redesigned Fork:

- Added side walls
- Minimized deflection (max = 0.0007mm)
- Possibility for a 1-piece design
- Tested a new design without a back wall to minimize the amount of material used
- Future designs are possible with smaller bolts and thinner Aluminum or Steel



Fork with Walls and no Back Plate

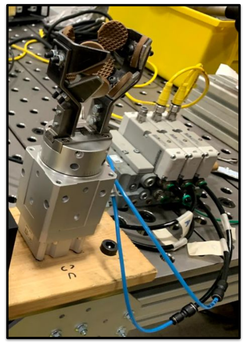


Fork with Walls Deflection Simulation

3D Printed Models

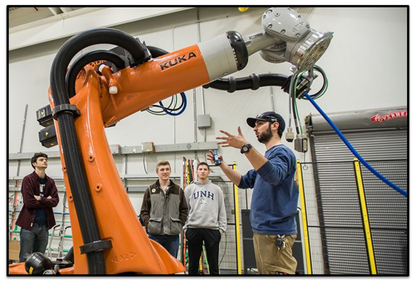
Redesigned Grippers:

- Bolted connections
- Increased contact
- Rubber finger surface
- Exact symmetry and fit
- Easily adaptable
- Decreased size
- No cap to bolt contact
- Quick and consistent application

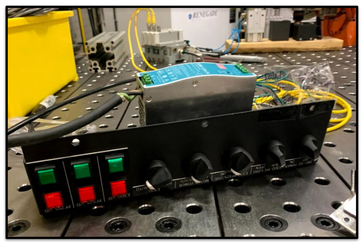


Testing

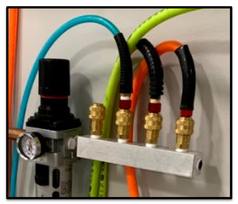
- Tested the different stationary forks for deflection
- Secured stationary fork and rotating actuator to testing table
- Created pneumatic system involving switches to control actuator speed and rotation
- Controlled robot arm via controller to make precise movements and actions, in real time and with coded moves
- Both sides of the design were tested by hand, with manual robot control and coded robot control
- Carbon fiber ABS



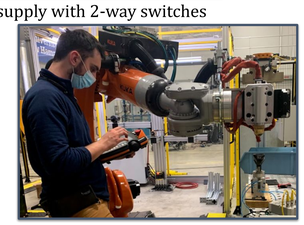
Equipment For Testing (Pneumatics, Electronics, Gauges)



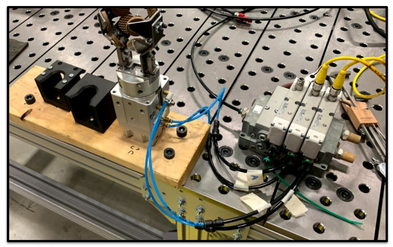
12V DC power supply with 2-way switches



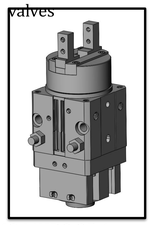
115 Psi air supply and pressure gauge



Kuka 6 axis robotic arm



Bolted fixture mounting & 5 way-2 position Air valves



SMC-MHRQ 25 Actuator

0.005” Increment Dial Gauge

Conclusions

- Redesigns drastically reduced all deflections and misalignments allowing for repetitive use
- Reinstate detents or over semi-circle contact area for the fork could secure the cap and prevent forward tilting
- Thinner rubber surface could make cleaner contact from the grippers to the cap
- This modular prototype could be adapted for multiple and varying cartridge applications

The Road Ahead

- Manufacturing the final aluminium fork
- Model the fork with exclusively side walls
- Adjust tolerancing
- Specify all high temperature or wear materials
- Make in-depth design recommendations for future utilization

Acknowledgements

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