Mechanical Fixture for Surface Treatment of Thermoplastics

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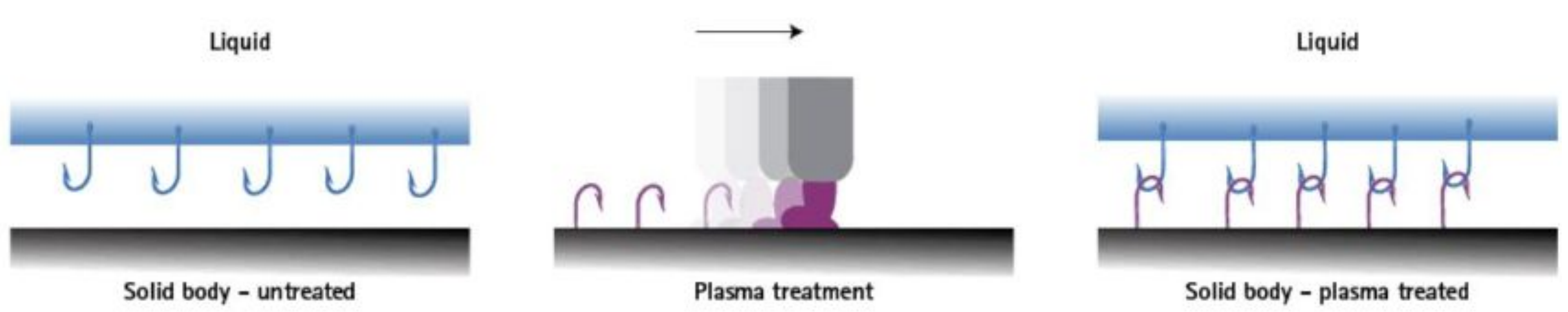
INTRODUCTION

Thermoplastic matrix composites are currently being researched as an alternative to current aerospace grade thermoset composites as they offer cheaper manufacturing options and improved recyclability. One issue with thermoplastic composites is the difficulty of repairing them. Adhesively bonded patches show the most promise, but the low surface energy of thermoplastics makes adhesive bonding difficult with epoxy or thermosets. A solution is to treat the surface with atmospheric plasma prior to bonding to increase the surface energy.

A $50,000, 5-axis robotic arm is currently being used for this purpose, but it is expensive and difficult to use. A mechanical fixture designed specifically for this use is desired.



CORE FUNCTIONS

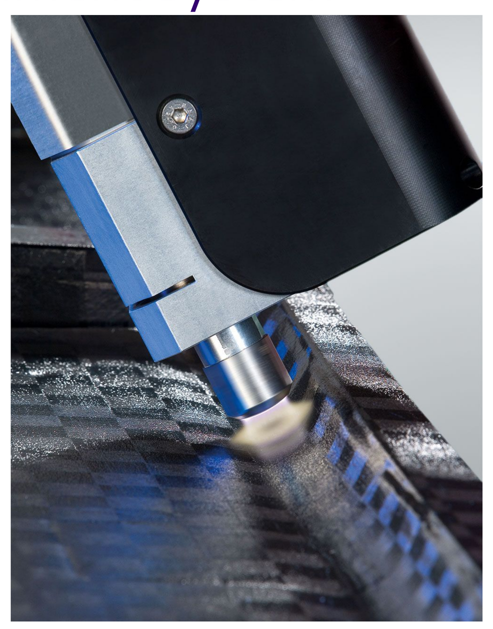
"To develop a way to prepare thermoplastics for repair on damaged aircraft panels by directly attaching a portable mechanical fixture onto the fuselage"

Design Requirement/Considerations:

-**Ease of use:** ergonomics, set up time, portability, required training
-**Affordability:** low upfront cost, low maintenance cost
–**Functionality:** moves plasma head for thermoplastic repair, securely attach to curved surface
–**Safety:** meets FOS requirements, fixture securely holds plasma nozzle, emergency shutoff, redundant attachment system

Fixture Specifications:

- Speed: 0.05-0.5 in/sec
- Surface to Nozzle Off-set: 0.5–2 in
- Max Treatment Area: 2ft X 2ft
- Raster Overlap: 10%
- Target Weight: 35lbs



RD2004 Plasma Nozzle

MECHANICAL ENGINEERING
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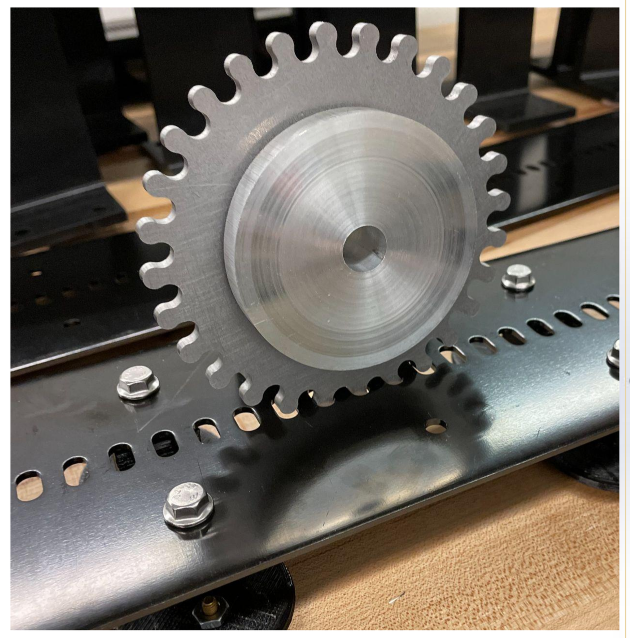
DESIGN AND DEVELOPMENT

Design Approach

The design consists of two flexible, spring steel racks with a series of uniform holes that a pinion can ride along. The gantry will have two gears attached on both sides of the rack driven by a motor. The gantry itself will consist of a pair of motors for actuation along the track and across the fixture. The plasma nozzle will be clamped and belt driven across the fixture.

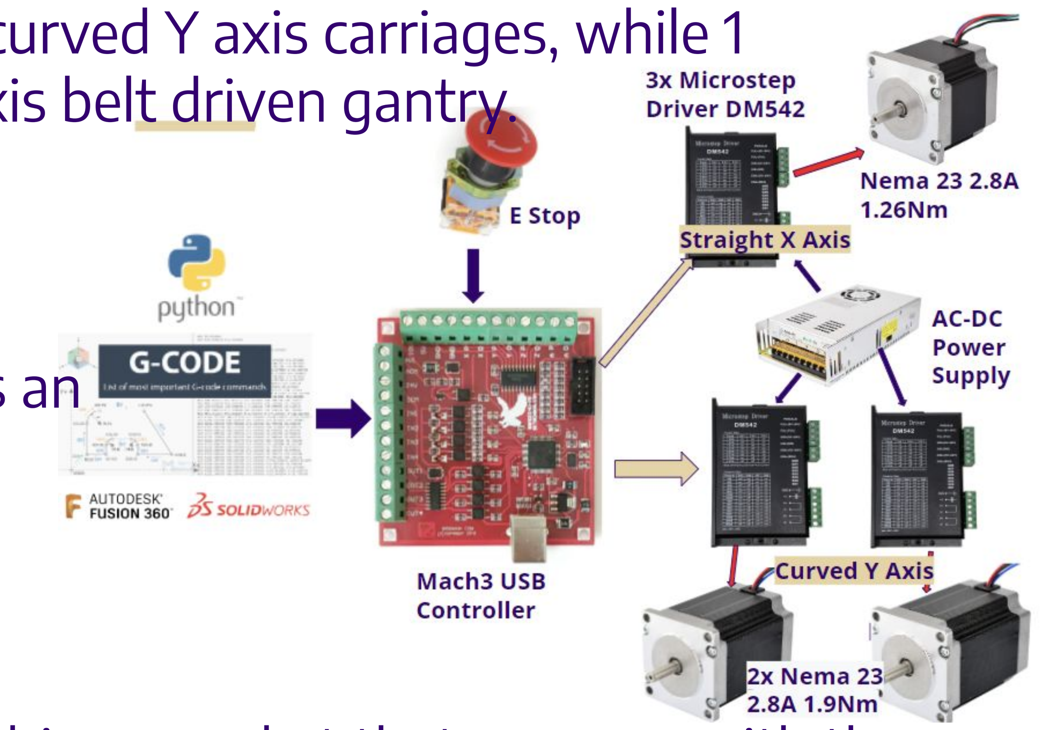


Rack n Pinion Interface

System Architecture

1. G code is generated for the surface treatment path which is imported into the Mach3 software.
2. The Mach3 Usb Controller outputs signals to 3 microstep drivers that applies power and torque output to 3 NEMA 23 Motors.
3. 2 NEMA 23s control the curved Y axis carriages, while 1 controls the straight X axis belt driven gantry.

If something goes wrong in operation, there is an Emergency Stop available as an added safety feature.

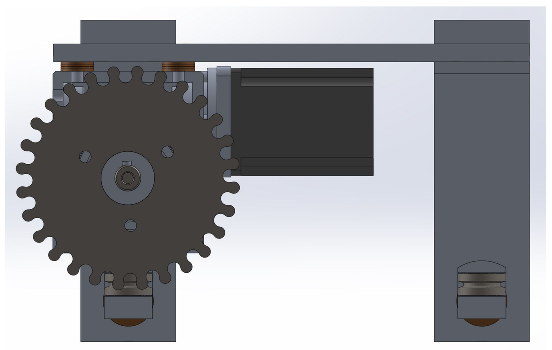


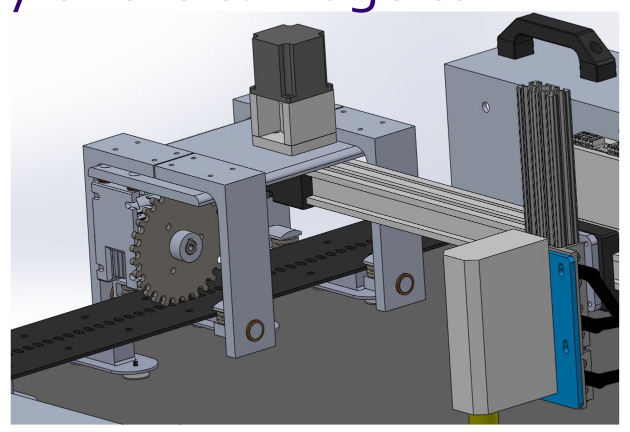
Carriage Design

Each carriage is driven by a drive sprocket that engages with the flex track. The drive sprocket is controlled by Nema 23 stepper motor through a speed reducing worm gearbox.

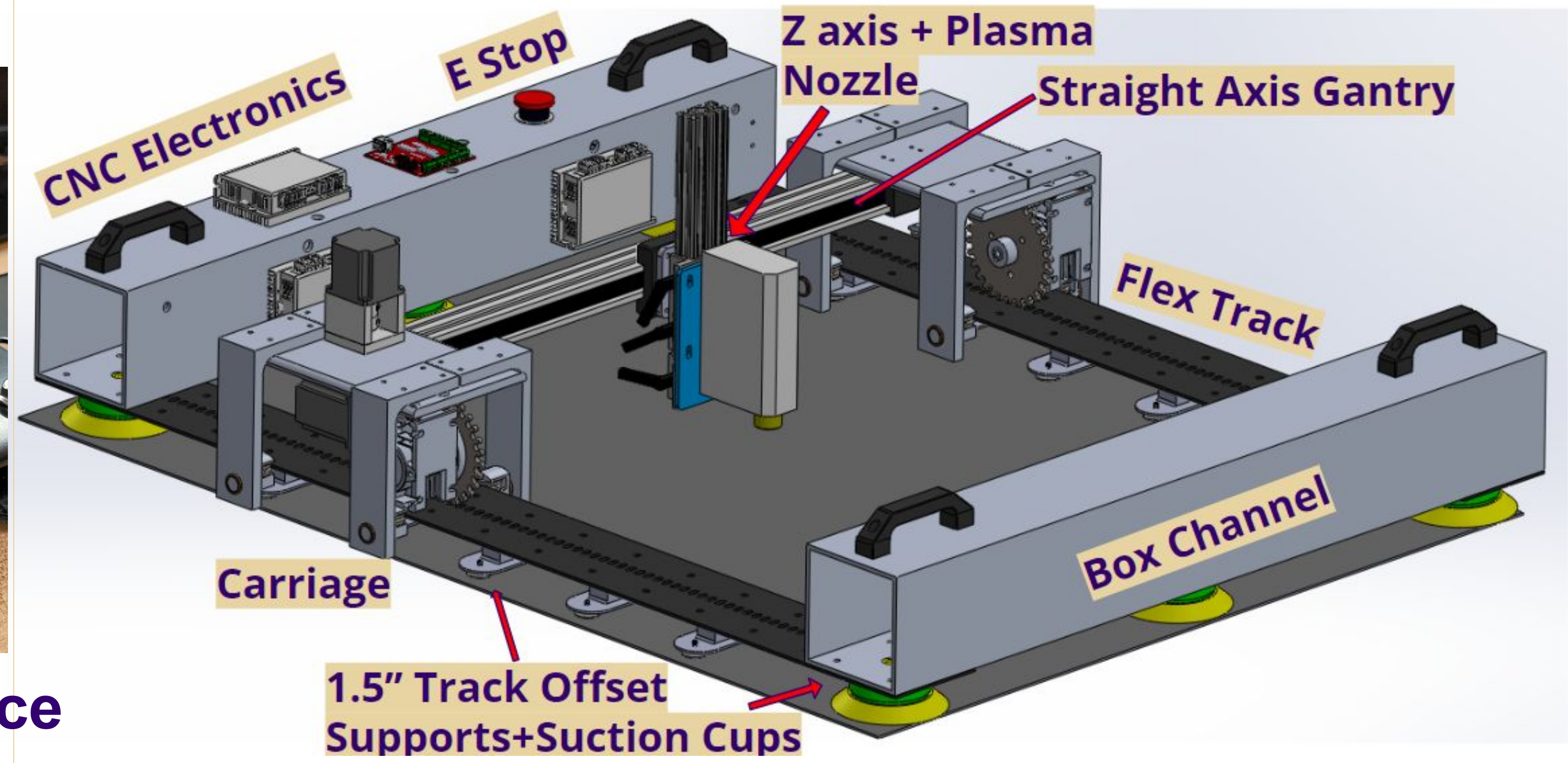
- Relatively few components, simplifies assembly/adjustability.
- Provides large torque multiplication (80:1)
- Large gearbox requires custom manufactured sprocket, complicating manufacturing and increasing weight.

Grooved track rollers guide the carriages along the tracks. The roller assemblies can rotate independently of the carriage to account for the track curvature.





Final Design



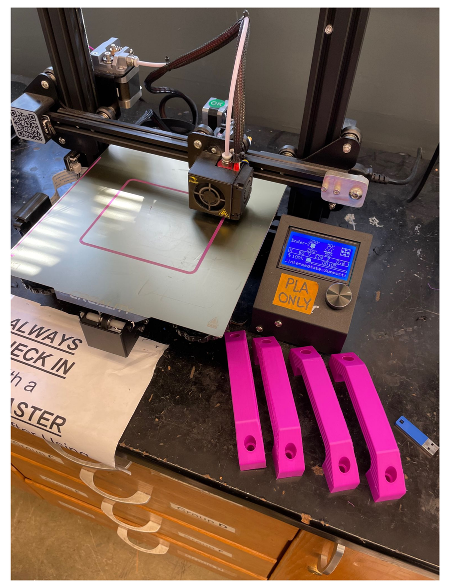
Mechanical Fixture CAD Assembly

Manufacturing

3D Printing (i.e. handles, suction cups, plasma nozzle)

Mill/Lathe 80+ hrs (i.e. sprockets, carriages, box channels, etc)

Purchased (i.e. flexible track)



CONCLUSION & FUTURE WORK

The fixture utilizes carriages running along flexible tracks with a rack/pinion system along the curved axis, and a belt driven gantry on the straight axis. In comparison to last year's Belt Gantry Capstone, this design ensures improvement of structural integrity, drive train, and binding issues. Future work could include constructing a redundant attachment system, reducing weight, and integrating Boeing's commercial suction cups. This product is applicable to aircraft structural repair.

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Mechanical Engineering Capstone Exposition
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