Mechanical Fixture for Surface Treatment Process Control

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INTRODUCTION

Current repair methods for thermoplastic contoured surfaces utilize a 5-axis robot arm requiring extensive training and setup.

Problem Statement

Our project aims to reduce complexity by creating a 3-axis fixture that securely mounts to curved surfaces enabling complex surface treatment operations.

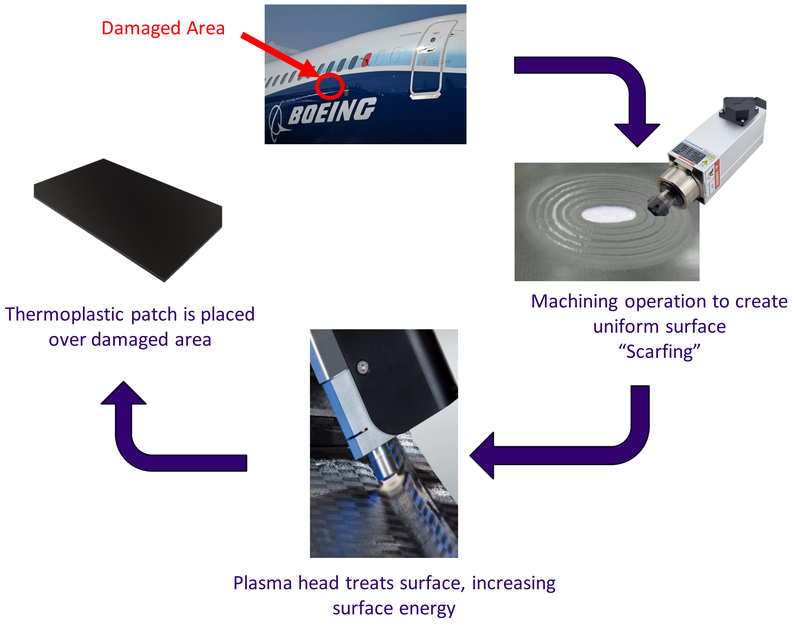
CORE FUNCTIONS

Functionality:

- **Attachment**: Able to attach to curved surface securely
- **Flexibility**: Able to conform to cylindrical curved surfaces (120in minimum radius)
- **Control**: Manipulate toolhead in XYZ using G-code

Specifications:

- Speed: 0.05-0.5 in/sec
- Curvature: 120in radius
- Z-axis travel: 4 in
- Max Treatment Area: 2ft x 2ft
- Target Weight: 80lbs total



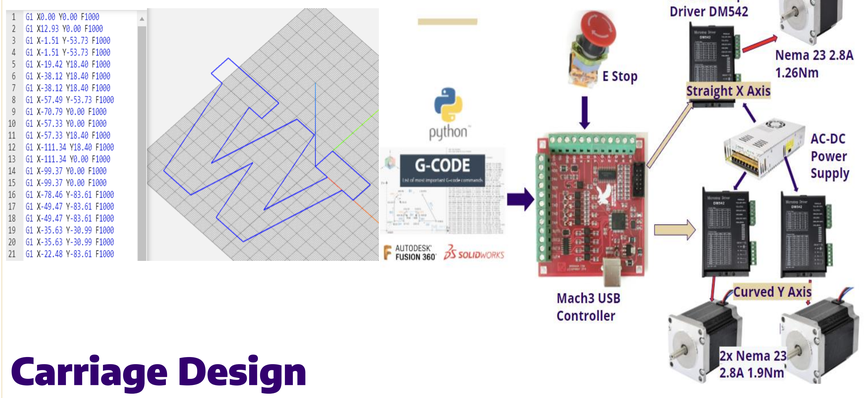
DESIGN AND DEVELOPMENT

Design Approach

- Utilize 2 rigid axes and 1 flexible axis to bend to the curved working surface.
- Navigate carriages along the bent axis with a rack and pinion relationship.
- Use an array of suction cups for strong surface attachment.
- Take advantage of aluminum and PLA components for weight reduction.

System Architecture

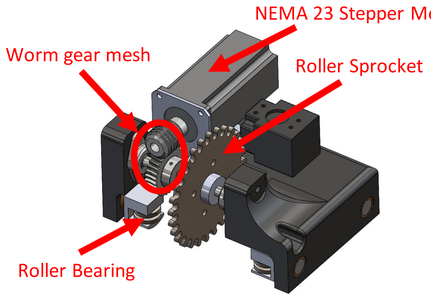
- G-code is generated using Python and imported into Mach3
- G-code signal outputted to (4) microstep drivers and transferred to Z-axis + (3) stepper motors

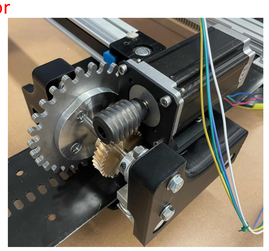


Carriage Design

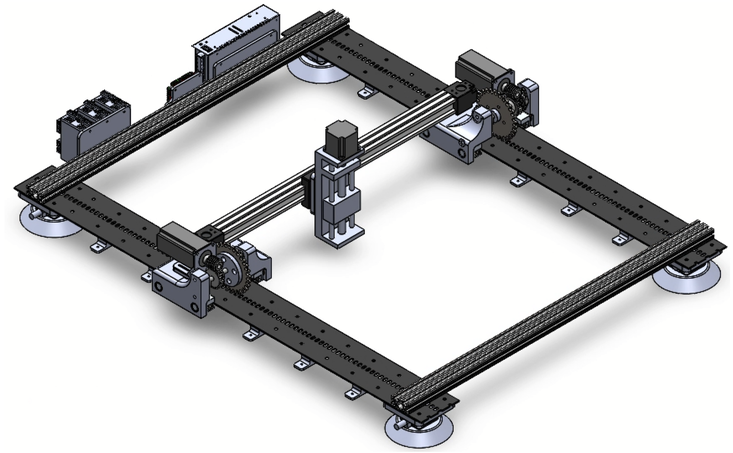
3D printed carriage assembly contains:

- NEMA 23 high-output stepper motor
- Worm gear mesh (15:1 gear ratio to achieve correct torque)
- Roller sprocket (interface with the flex track)
- Roller bearings (interface with the flex track to maintain constant spacing with the roller sprocket)





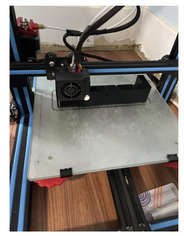
FINAL DESIGN



Mechanical Fixture CAD Assembly

MANUFACTURING

- Additive Manufacturing
- Mill/Lathe/Drill Press
- Commercial off the shelf parts



CONCLUSION

- The fixture utilizes carriages running along flexible tracks with a rack/pinion system along the curved axis
- Suction cups attach the fixture to the surface
- A z-axis ball screw was also added as a 3rd axis
- 15% weight reduction while adding a 3rd axis

FUTURE WORK

- Improve stability in non-horizontal orientations, especially while mounted upside down.
- Optimize tool attachment.
- Switch to pneumatic suction cup system.

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Mechanical Engineering Capstone Exposition
May 30th, 2023, Husky Union Building,
University of Washington, Seattle