Customizable Carbon Fiber Manufacturing

PURDUE UNIVERSITY
Mechanical Engineering

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This project introduces a reusable, reconfigurable mold that uses a motorized pin array and flexible membrane to create custom surfaces for carbon fiber layup, replacing one-off wood or foam tooling. The system converts a CAD model into a height map that automatically sets each pin using an XY motion stage and linear actuator, then locks the pins to provide a stable forming surface within a 1 ft by 1 ft area. With push-button operation, standard 120 V power, and interchangeable membranes, the mold enables rapid turnaround between unique part geometries while reducing material waste, setup time, and overall cost for low-volume composite production.

Problem Definition

When laying up carbon fiber, it is necessary to machine a custom mold out of wood or foam, that will be thrown out after the custom part is done curing. This is time consuming, costly, and a waste of resources.

Our vision: We aim to streamline carbon fiber manufacturing to reduce waste and time when producing molds for laying up carbon fiber

Requirements

Customer Requirements:

- Mold Area: 2x2 ft
- Mold Speed: ~30 Minutes
- Mold Fidelity (Min. radius of curvature): 1”
- Cost: Over $1000

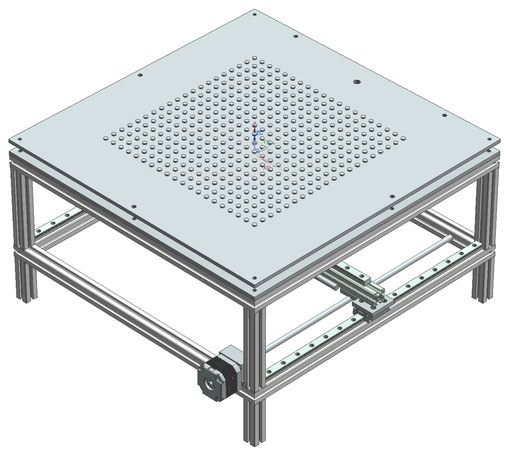
Other Requirements:

- Weight: Less than 100 lbs
- Pin Range of Motion: 2.5 “
- Load Capability per Pin: 1 N
- Base area: under 2x2 ft
- Power source: must be powered by standard 120V wall outlets
- Mold Forming: must be able to automatically form mold once input file is provided

Key Design Features

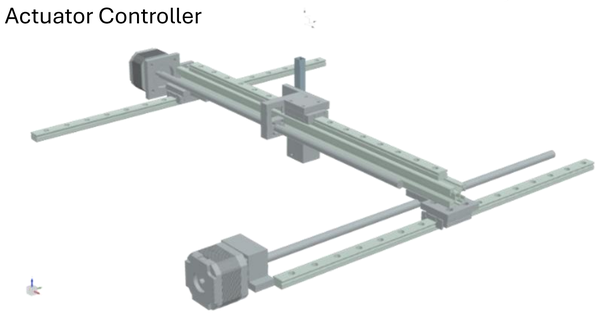
Starting with the CAD, the model is turned into a point cloud.

- Using the point cloud data, the device actuates the pins to the required height to form a surface.
- Once each of the 400 pins are set, a mechanical lock is hand actuated to lock in the pins.
- Then, carbon fiber is layed up over the pins. A membrane can be used to smooth out the pins.
- After the carbon fiber is modeled, the machine can be reset.



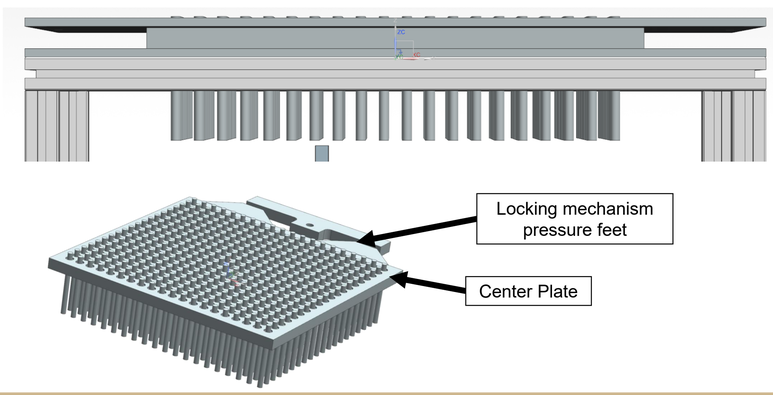
XY Motion System

- The motion system is driven by stepper motor driven lead screws. The system is constrained by linear rails.
- The stepper drivers are TB6600 and the motors are NEMA 17 steppers
- The actuator is a Actuonix P16-100-22-12-P controlled by a Actuonix Linear Actuator Controller



Pin Locking System

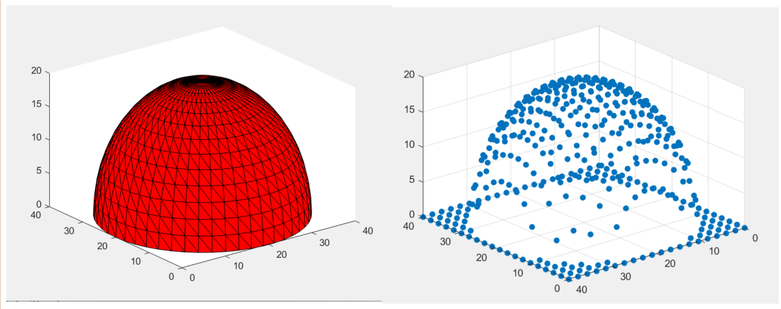
- The pins are held in place by three plates.
- The center plate is moved by the locking mechanism and has o-rings on each side.
- When the plate is locked in, it places the pins in double shear, increasing the holding force.



Model to Mold Process

With our project, the aim is to be able to quickly and accurately reproduce a digital model for flat carbon parts.

The user of our project begins by creating their CAD prototype. The next step is to export their part as an STL file. Then, the MATLAB algorithm our team created exports an array of pin heights.



The last step is to simply import this array into the program we have written on Arduino IDE and upload it.

Obtaining the array takes a few minutes and running the table to set the pins to the correct height takes around 30 minutes.

Results

Please see testing results at the following link:

Customizable Surfaces for Carbon Fiber Manufacturing through Dynamic Pin Array