Can Crusher

PURDUE UNIVERSITY
Mechanical Engineering

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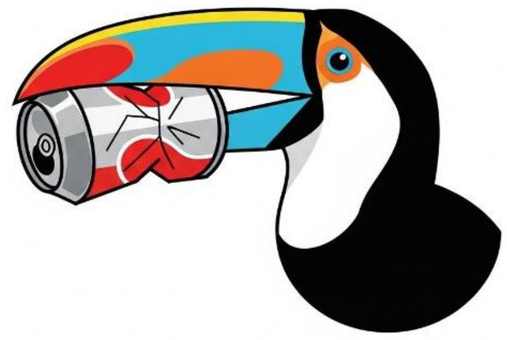
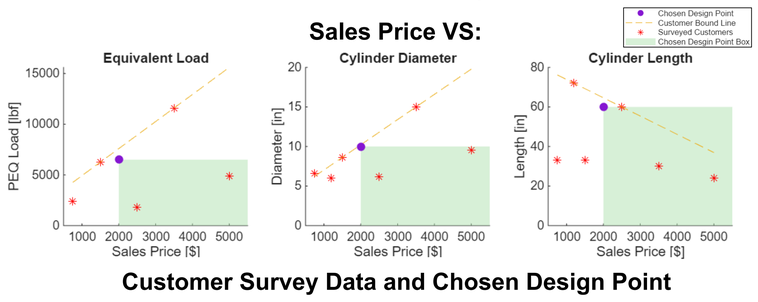


The Can Crusher is a structural testing device to qualify airframes for student rocket teams. Of six student rocket teams surveyed, all reported the need for structural testing, and five were not satisfied with their current testing capabilities

The Can Crusher can apply a range of load combinations up to 4500 lbf compression and 975 ft-lbs bending. Load is applied by three pneumatic actuators, each pulling up to 750 lbf, with a pulley doubling their effective force. The output force of each actuator is controlled by adjusting a manual regulator with a stepper motor using a closed-loop controller. The device is validated by simulation a customer's qualification tests correlation strain in an aluminum tube to analytical predictions under multiple load combinations.

Business Case

- Over 200+ student rocket teams in US competing in various competitions
- 4/6 surveyed teams would spend $1500+ on device that meets requirements above
- No current competitor on the market
- Accepts customer's flight hardware to simulate realistic boundary conditions
- Applicable to other academic applications:
  - Student car teams, composites research



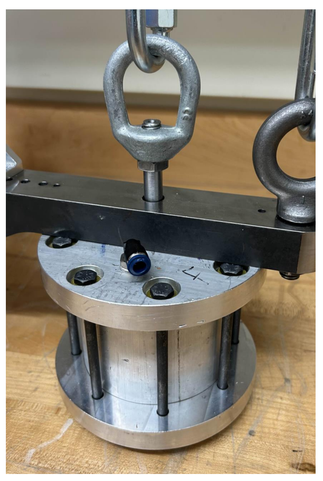
Customer Survey Data and Chosen Design Point

Customer Requirements

- Sale price less than $1500
- Apply 2900 lbf compression and 750 ft-lbs bending simultaneously
- Accept airframes 6-10" diameter, ≤ 36" long
- Use min 90 psi shop air and require minimum two operators
- Can be safely disabled and depressurized at any time remotely
- Test article strain correlates ±10% to prediction in validation test

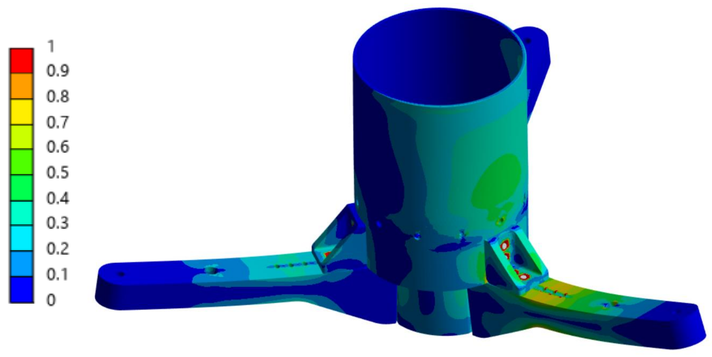
Pneumatic Actuators

- Pulls 786 lbf on 90 psi air supply
- Designed to AMSE BPVC Standard
- Each actuator hydro-proofed to 100 psi
- 2X dynamic O-ring seals



Structural Design

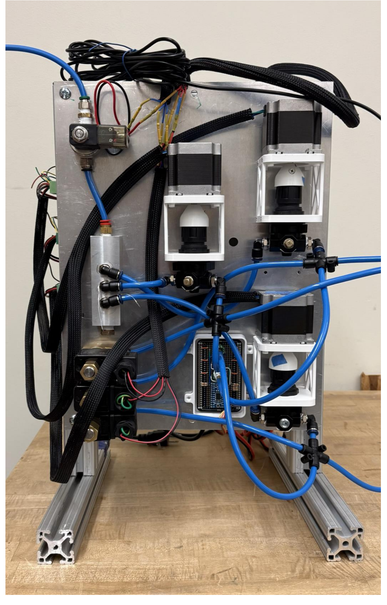
- Strut and hub design minimizes stock cost and machining complexity
- Bolted joints designed to NASA-STD-5020
- Chain tension adjustable with jam nuts
- Structural safety factors analyzed in full-assembly Ansys FEM in bounding load cases



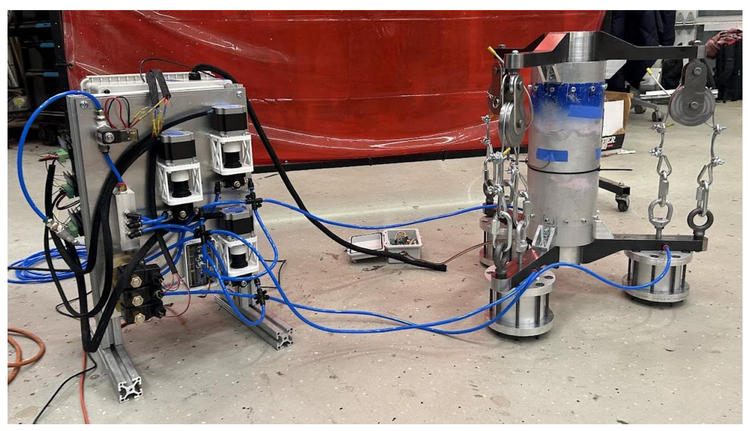
Structural Failure Index in Max Bending (1 = Failure)

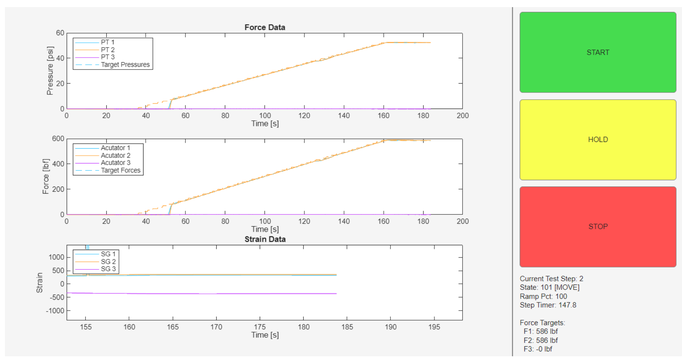
Pressure Controller

- Controls forces by adjusting pressure in cylinders
- Closed-loop controller adjusts regulators with
- stepper motors
- E-stop solenoids safely depressurize in < 2 seconds
- Arduino interfaces with hardware, controller in MATLAB



Final Prototype

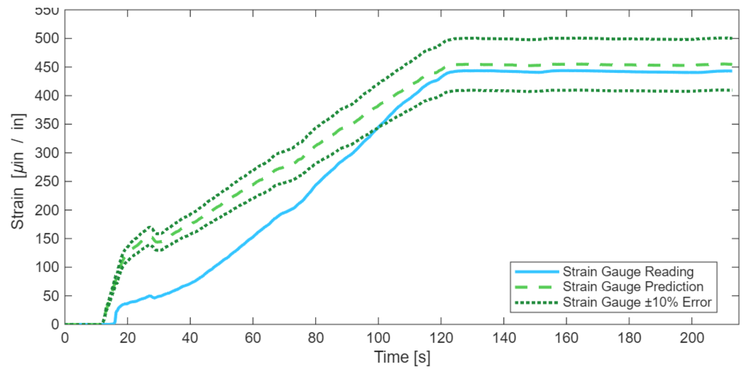




Test Control GUI Mid-Test

- Test stand integrates with fluids panel using push-to-connect NPT fittings
- Interactive GUI to monitor data and operate test
- Load steps, ramp rate and automatic holds can be specified by user
- Automatic hold if anomaly detected

Testing



Strain in Aluminum Tube Under Max Bending Load

- Simulated customer's "qualification test" on aluminum tube
- Performed five tests bounding all load combinations and orientations
- Measured strain in aluminum tube with strain gauges
- Steady state strain correlated within ±10% of analytical prediction in all tests

Structural test stand to qualify airframes for student rocket teams.

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