Mechanical Engineering
CAL POLY

Acknowledgements:
Eileen Rossman - Project Advisor
Eric Pulse - Mustang 60

3 IN 1 MEDICAL LANCET

MARISSA KOSKI, GAGE VOGTLIN, JONATHAN PANELLA, BENJAMIN NEYLAND

SPONSOR:

TIM NURGE, PARAMEDIC

SAN LUIS AMBLUANCE

BACKGROUND

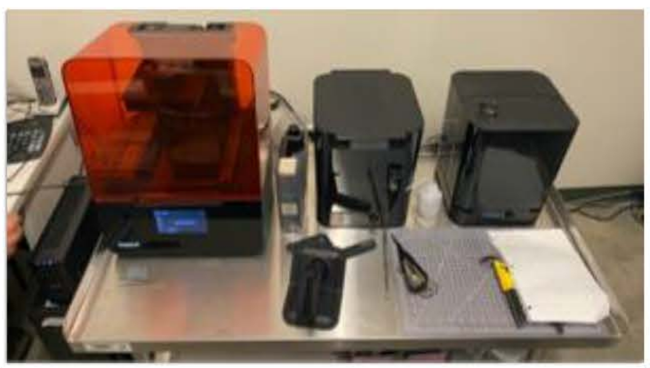
The current blood glucose testing method involves multiple ancillary components, which is inconvenient, especially in emergency situations where time of use is key.

OBJECTIVE

First responders and diabetics need a quick, sterile, and convenient way to sample blood for glucose testing because glucose levels are a vital metric in emergency situations.

MANUFACTURING

- Small component size
- SLA Printing with Formlabs Form 3 printer
- Drill and glue sourced lance needle
- Hand assembled
- Integrated snap fits and pins hold device together

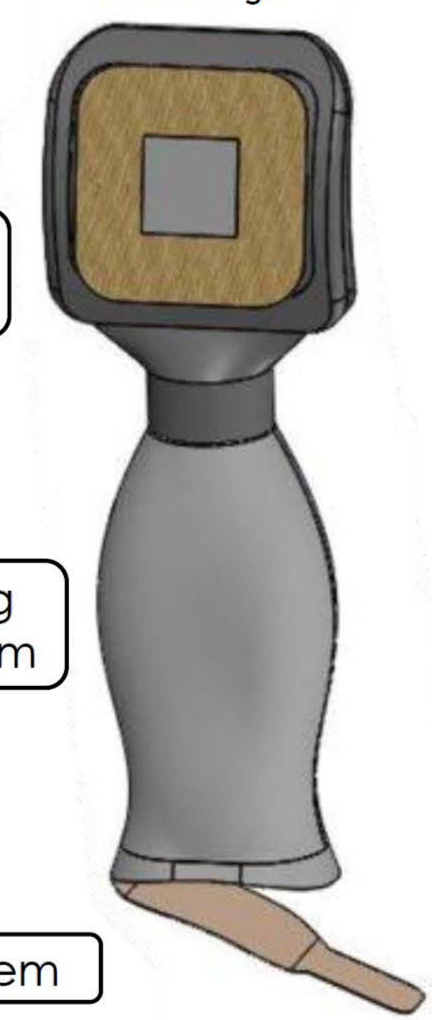


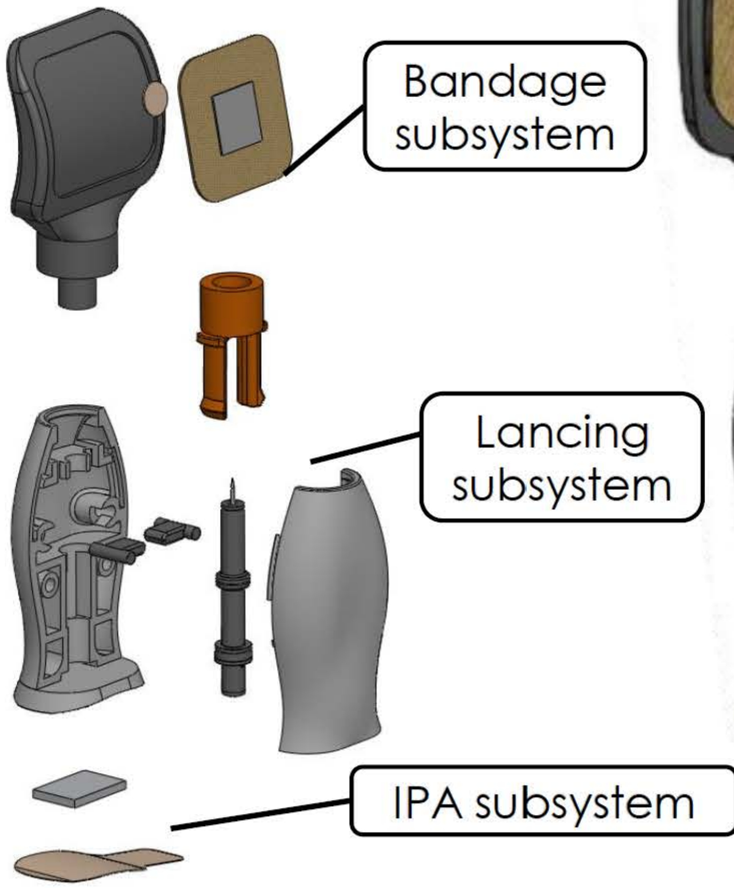
DESIGN

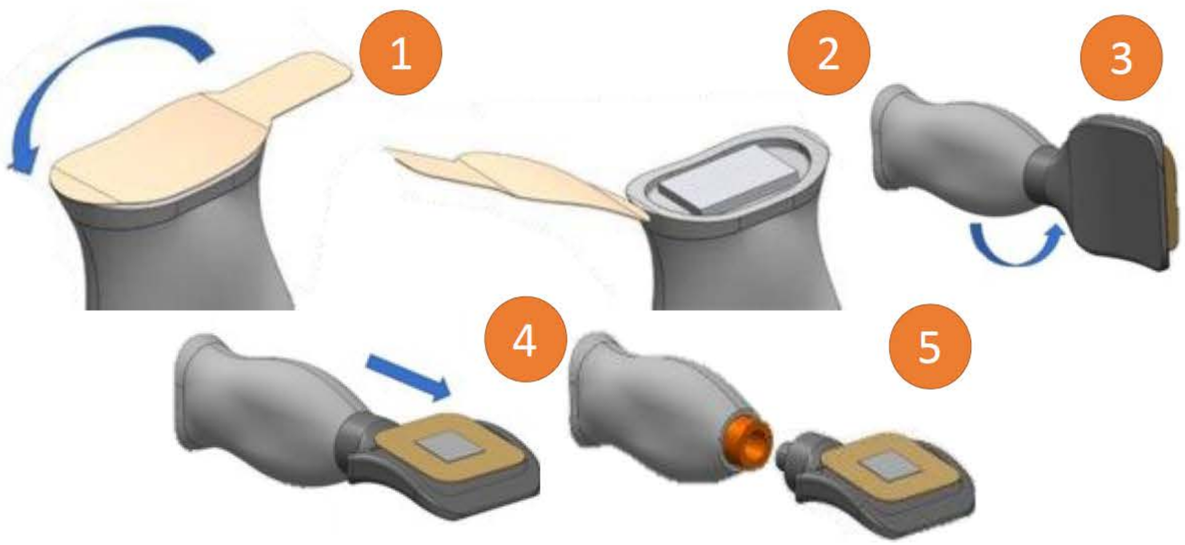
- Iterative process
- User centered design
- Surveyed focus group
- Ergonomic considerations

PDR Design

Final Design

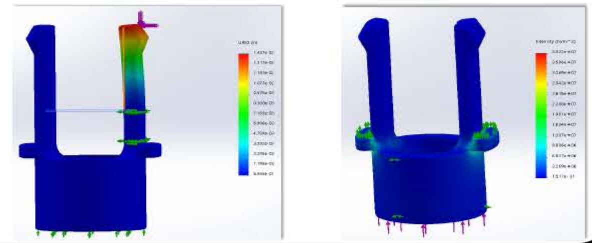






ANALYSIS

- FEA of lance hard stop
- FEA of trigger in mechanism
- Transient spring damping system displacement using MATLAB script



TESTING

Test metrics compared to the current blood glucose testing process to assure a competitive product.

Time of Use: *69% improvement*

3 in 1 Lancet: 23.53 seconds

Current process: 40 seconds

Prick success rate: *11% improvement*

3 in 1 Lancet: 100%

Current process: 90%

Needle Displacement:

Average needle lance distance = 1.05 mm

MOVING FORWARD

This design gives our sponsor the basis to develop the product further, seek investment, and start the patent process. We hope to see this product realized, scaled, and in the hands of first responders.

Team: Cole Ramsdale, Josh Sparrow, Kyle Archibald, Fernando Romero
Advisor: Professor Eileen Rossman
Sponsor: Professor Roger Benham

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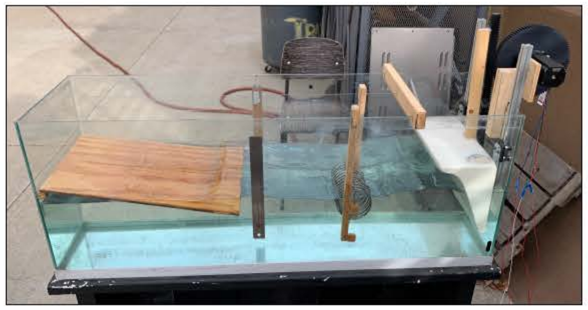
COILReef™ Wave Energy Dissipation

COILReef™

CAL POLY College of Engineering

Physical Testing


Ravine Water Park Wave Pool
2^4 Full Factorial Test


Small Scale Wave Tank
2^3 Full Factorial Test

Project Description

Construct, test, and investigate the design of a coil-shaped structure intended to dissipate ocean wave energy, thereby mitigating coastal erosion. Perform theoretical simulation and physical testing of the COILReef™ to validate the concept.

Background

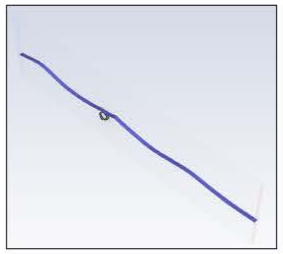
Current wave energy dissipation designs such as rock jetties and breakwaters are high cost and permanent solutions that sometimes produce undesirable effects. The COILReef™ coil geometry is designed to cause destructive interference to the rotational wave particle motion. The fabrication method and removability of this design allow for a low-cost alternative to existing erosion control structures.

Simulation Analysis

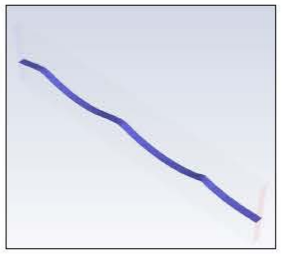
Computational Fluid Dynamics (CFD)

- Large diameter
- Small spacing
- 0.6 m wave height
- 7 m wavelength

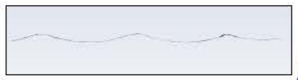
Test with coil (iso view)



No coil (iso view)




Side view


Side view

Final Design Prototypes

2 of 4 prototypes:

Top:
- 2ft Diameter
- 8" Coil Spacing

Bottom:
- 1ft Diameter
- 4" Coil Spacing

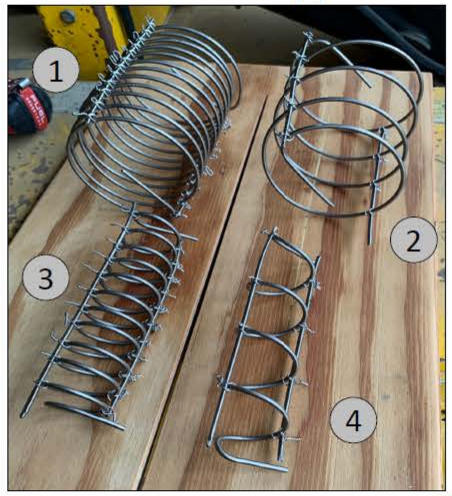
Wave Tank Test Prototypes

Coil 1:
- 4" Diameter
- 0.5" Coil Spacing

Coil 2:
- 4" Diameter
- 1.5" Coil Spacing

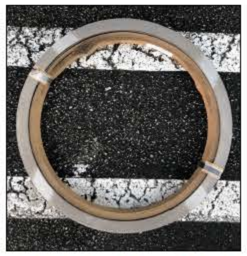
Coil 3:
- 2" Diameter
- 0.5" Coil Spacing

Coil 4:
- 2" Diameter
- 1.5"Coil Spacing



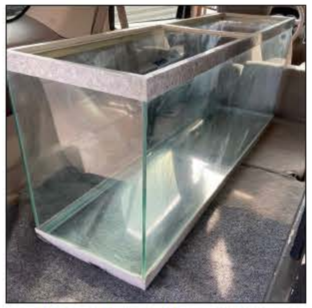
Manufacturing

Coil Test Prototypes:

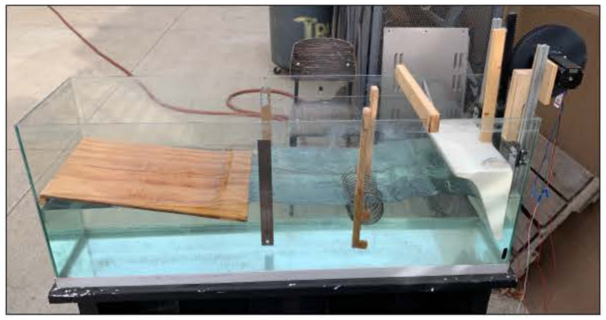

Cut Titanium Strip metal to length


Spot weld Coil Ribs to Material Band


Bead Roll 2 Ribs and Coil Material Band


Purchased Tank

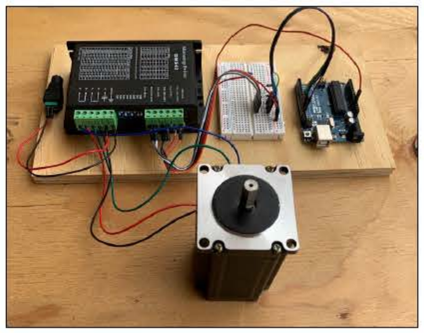
Wave Tank:


Woodwork Beach and fixture slots

3D Print Rack & Pinion


Fiber glassed foam wedge

Epoxy t-slot quad tracks to tank & mount rollers


Stepper motor assembly

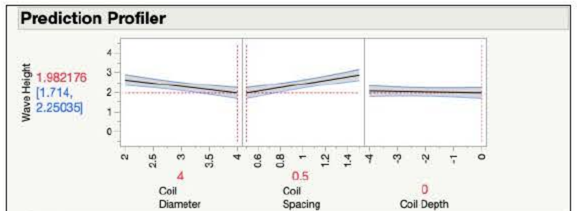
Conclusions

Sorted Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Coil Spacing(0.5,1.5)	0.3253534	0.051345	6.34	<.0001*
Coil Diameter(2,4)	-0.191008	0.051345	-3.72	0.0003*
Coil Diameter*Coil Spacing	0.0814218	0.051345	1.59	0.1147
Coil Diameter*Coil Depth	-0.05224	0.051345	-1.02	0.3104
Coil Depth(-4,0)	0.0444685	0.051345	0.87	0.3877
Coil Spacing*Coil Depth	0.0397847	0.051345	0.77	0.4395

Coil spacing and diameter are significant factors

Prediction Profiler



Optimal Settings

Setting	Coil Diameter	Coil Spacing	Coil Depth	Wave Height	Wave Height Lower CI	Wave Height Upper CI
Optimal	4	0.5	0	1.9821761	1.7140003	2.2503518

Maximum effect of wave height reduction occurs with largest coil diameter, smallest spacing, and coil placed at surface depth

Compact Dielectric Immersion Cooling System

Josh Hannaman • Marshall Reid • Salvador Landeros

Fall 2021

Sponsor:
Aria Technologies, Inc.
Dan Rodman
Advisor:
Eileen Rossman

PROBLEM

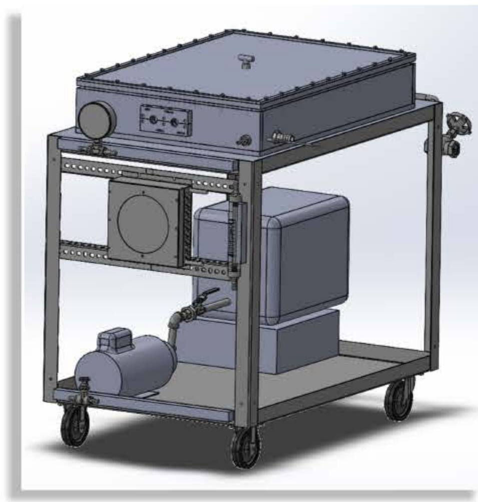
- As data centers continually increase the power density of their IT equipment, this level of cooling has begun to push the limits of traditional air-cooled systems
- Liquid cooled systems that are commercially available are very bulky and take up a large amount of space

OBJECTIVE

- Aria Technologies wants a liquid immersion cooling solution that can be integrated into an existing server rack with a cooling capacity of 750 to 1000 watts per server while achieving an operating temperature below 55°C

SPECIFICATIONS AND FINAL DESIGN

- Single stage liquid cooling system utilizing only sensible heat transfer
- Electrical input of 120V AC
- Designed to be mountable within a standard 23" telecommunications rack
- Active temperature monitoring and reporting
- Completely liquid sealed
- A low operating pressure, less than 14.7 psig, required for safe operation of the system
- Designed to meet Open Compute Projects' (OCP) immersion system requirements
- Materials used were designed around compatibility with the dielectric fluid to prevent failure



ANALYSIS AND TESTING

System Pressure

$$\left(\frac{p_1}{\rho g}+\alpha_1\frac{\overline{V}_1^2}{2g}+z_1\right)-\left(\frac{p_2}{\rho g}+\alpha_2\frac{\overline{V}_2^2}{2g}+z_2\right)=\sum H_l$$

System Cooling Capacity

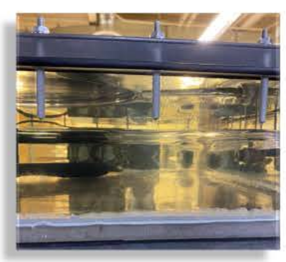
$$\dot{Q}=\dot{m}C_p dT$$

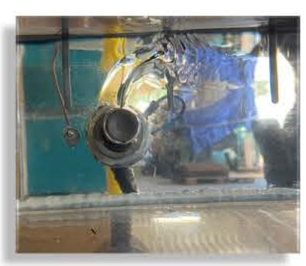
Testing

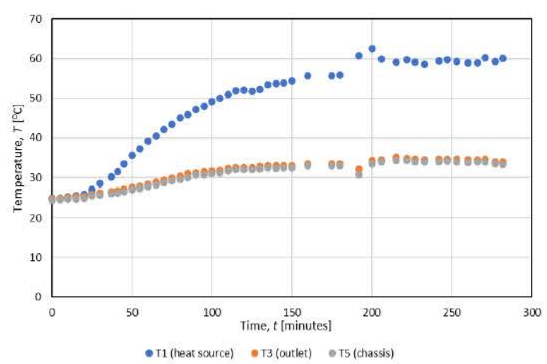
- **Structural Prototype**
  - Chassis base/lid interface testing
    - Gasket
    - Compression system
  - Air bleeder valve testing
  - Chassis/Cable interface testing
- **Verification Prototype**
  - System pressure and flowrate testing
  - System cooling capacity and temperature testing

RESULTS

- Our systems operating point is 10 psi at 1.5 gallons per minute through the inlet hose with a slight negative pressure within the chassis
- The system achieved a steady state temperature of 60 °C after 200 minutes of continuous application of 750 watts of thermal energy.
- The EC-120 dielectric fluid's characteristics change drastically as heat is added. During the cooling capacity test, a boundary layer was created in the fluid due to large temperature gradients within the chassis.
- The hot, less dense fluid remained in the top half of the chassis while the cool incoming liquid remained in the bottom half of the chassis. This created an immiscible-like fluid flow within the chassis preventing the system from maximizing heat transfer within the fluid, and consequentially, to the surrounding air.







MANUFACTURING

Waterjet

- All 6 pieces of the chassis were cut from a single 48" x 48" x ½" sheet of polycarbonate

3D Printed Cable Gland Assembly

- The interface for server cables and chassis wall was 3D printed out of PLA

Drilling and Bonding

- The holes in the chassis were drilled to secure the various components including quick-disconnects, cable gland assembly, air relief valve, thermocouples, and heating element.
- All chassis walls and component were bonded with structural epoxy and sealed with silicone
- The largest manufacturing challenge: lid/base interface
  - Drilled 13/64" holes every 3" along chassis wall
  - Epoxied 34 #10-32 stainless steel all-thread into each hole
  - Drilled 7/32" holes in 1/8" x ½" steel strips, chassis lid, and punched holes out of neoprene gasket
  - #10-32 stainless steel flange nuts are used to compress neoprene gasket 0.078" (31%)

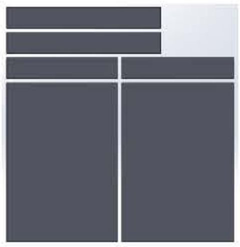
3D Printed Cable gland assembly

Bonding and sealing

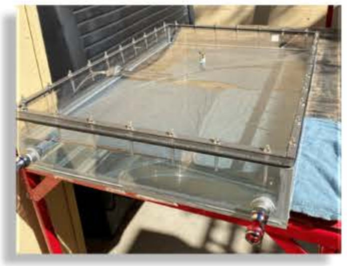
Compression Seal

Jig built and used for setting all-thread in uniform arrangement

Waterjet



Chassis Assembly



Chassis all-thread, gasket, and steel strip seal testing

Fiberglass Mat Slitter Blade Sharpener- W23

Mechanical Engineering CAL POLY

Bradley Smith • Mark Breaux • Carlos Paredes Espinoza • Esteban Carrillo

Sponsor:
Javier Davila
Javier.Davila@gaf.com
Advisor:
Eileen Rossman

PROBLEM

- General Aniline and Film (GAF) needs an online solution to sharpen their slitter blades without stopping production and minimizing employee intervention.

OBJECTIVE

- Design and build a device that will be tested on an off-line test bench that accurately sharpens the slitter blade profile.
- Device has the potential of being incorporated on their production line
- Minimize employee-machine interaction as much as possible.

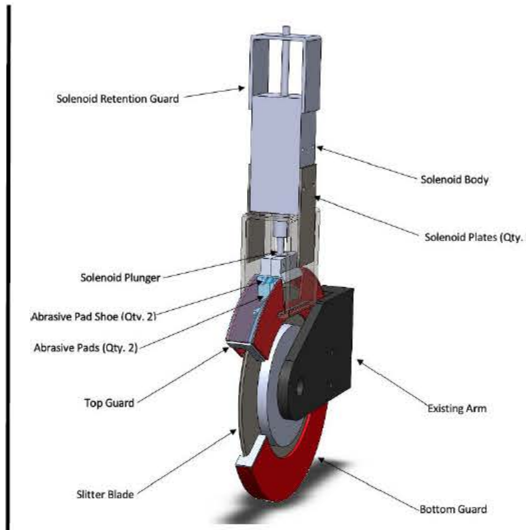
SPECIFICATIONS AND FINAL DESIGN

Top Guard Design

- Top guard supports solenoid assembly.
- Design bolts to Dienes blade assembly.
- Protects users from sparks and sharp blades
- Enough space to splice fiber glass roofing shingles.

Sharpening Assembly

- Solenoid connected to abrasive shoes/abrasive pads.
- Shoes and top guard designed for ease of maintenance and assembly.
- Shoes designed to create the 60° blade angle for crushing motion.
- Retention guard keeps the shoe from rotating during grinding operation.

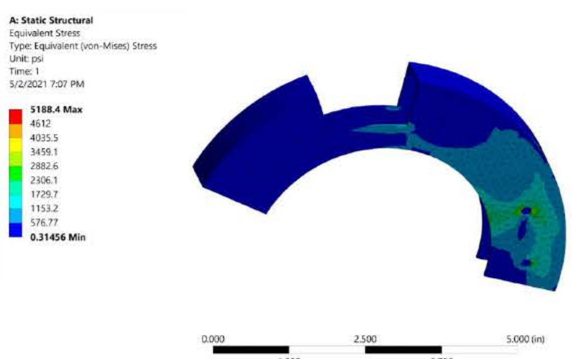


CAD Model

ANALYSIS AND TESTING

Computer Analysis Before Building

- Finite Element analysis was completed on the top guard to test its rigidity, strength and stiffness.



Testing

- Time Requirements for Sharpening profile – Evaluation of the time it takes to sharpen the blade to the desired 60° angle with any blunted edge profile.
- Abrasive Pad Life – Evaluate the life cycle of the pad measured in total effective grinding time.
- Variable Speed Capacity – Ensure the solenoid would be able to sharpen for all expected operating surface speeds.
- Solenoid Lifetime – Determine maximum solenoid duty cycle before failure.

MANUFACTURING

- Top guard cut via water jet and welded. These processes were outsourced.
- Abrasive shoes outsourced using additive manufacturing.
- Solenoid platform, retention guard, and solenoid adapter manufactured in-house.

Solenoid Platform

Milling Solenoid Platform

Top Guard

Tapping Abrasive Shoes

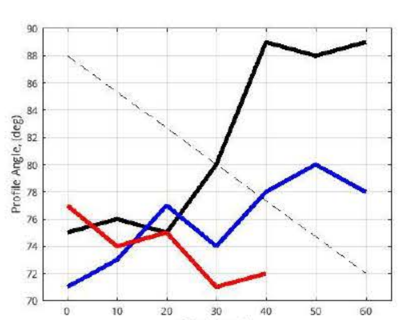
Abrasive Shoe Assembly

Plunger

RESULTS

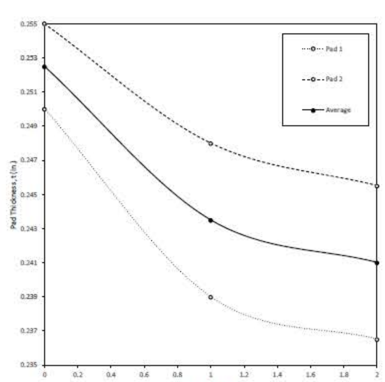
Profile Angle Testing:

- The opposite of the expected trend was observed due to solenoid misalignment.



Pad Wear Testing:

- Observed pad decrease as expected, about .010" per minute of use.



Test Bench Assembly

RECOMMENDATIONS

- Increase the gap where the blade slips under the top guard.
- Increase the thickness of the material used for the top guard.
- Used a concentric roller to mitigate vibrations during operation.
- Choose appropriate polarity and push direction on solenoid with a larger plunger diameter.

Gaylord Produce Removal

Marcus Lee, Jacob Perlman, Mark Loera, Carissa Kamm

Background

Currently, volunteers are manually emptying these Gaylord boxes (42"x48"x28") and the repetitive motion of reaching into the box can cause discomfort and lower back pain.

Objective
Design, build, and test a prototype tilting device to reduce the strain placed on workers, without damaging the Gaylord box or the produce inside.

Design Constraints
Device must support full Gaylord box which ways ~600-800lbs
Limited power source (no access to electrical outlets or fuel based devices)
Costs should be minimized for both operation, maintenance, and manufacturing
Must be a free-standing structure and movable by forklift
Easy to operate (requires minimal training)

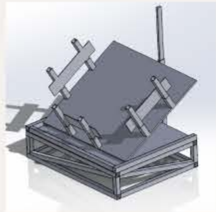
Design Process

Design, build, and test a prototype tilting device to reduce the strain placed on workers, without damaging the Gaylord box or the produce inside.


Once design goals and constraints were defined, the project went through initial stages of ideation

One of Initial Concept Designs of device were created out of material on hand and later CAD models were created in SolidWorks

Practical Prototype




Design Iterations

Final Design

- Utilizes electrical battery powered winch and pulley system
- Smaller in size to reduce occupied floor space
- Structural frame made of wood to reduce cost and weight
- Designed to be moveable via forklift
- Allows for a tilting angle of 45 degrees
- Tested to hold and tilt load of over 1000 pounds

Manufacturing

Cutting 2"x2" Steel Tubing to size using an abrasive saw

Drilling holes in wheel plates

Welding the Secure System together

Screwing together the Base Frame together

Clamping wood together while glue sets and dries

Testing

The testing completed was focused* on structural strength and verifying device capabilities and compatibilities. The device, designed to hold and tilt gaylords boxes of up to 800 lbs, was load tested up to 1200 lbs, and tilted loads up to 900 lbs within 6 seconds in testing. The compatibility functions with forklift were also directly tested via loading a pallet onto the secure system as well as moving the whole system on the forklift with no additional securing.

Secure System Load Test 1200LBS

Full System Load Test 1200LBS

Tilting load Test 900LBS

Forklift Compatibility Test

*Volunteer performance tests and ergonomics tests were planned but left incomplete due to delays in manufacturing and lack of gaylords box.

Conclusion

Recommendations
The main recommendations to improve our prototype for safer, more reliable use would be to:

- use a mechanical hoist over a mechanical winch, for a safer catastrophic failure scenario (A hoist would hold, where a winch would freely spool out)
- replace the wire rope connections from the secure system to the winch wire with a chain link or wire rope designed to hold loads in suspension.
- autolocking E-track to secure the device while tilting

Conclusion
Our team was able to design a prototype that satisfied the design goals of a more ergonomic way to remove produce from the gaylords boxes in a manner that is compatible with the Alameda County Food Bank. Our design takes up only a few square feet of additional space other than the gaylord box, is able to be loaded, unloaded, and relocated via forklift, and can be loaded and operated easily and quickly for more time to be able to be spent unloading the produce.

Acknowledgements

Special thank you to Eileen Rossman, Kevin Williams, Nehpi Derbidge, Shop Techs at Mustang 60, and our sponsors Marcos Trujillo and Leif Magnuson

Magnetic & Electromagnetic Landing Gear Uplock

Team: Garrett Donovan, Christopher Edward, Kevin Lee, Jason Szeto

Acknowledgements:
Dr. Eileen Rossman

Michael Allwein: Michael.Allwein@ga-asi.com
Caleb Bartels: Caleb.Bartels@ga-asi.com
Anthony Moreno: Anthony.Moreno@ga-asi.com

Background:

General Atomics Aeronautical (GA-ASI) operates all electric unmanned aircraft and wants to incorporate an electronically operated uplock with no moving parts for the landing gear and bay doors. There are no existing electromechanical uplocks on the market for this use case and GA-ASI does not want to use hydraulically actuated uplocks.

Design Specifications:

Specifications	Discrete System	Distributed System
Unpowered Hold Force	150 lb	25 lb
Powered Hold Force	15 lb	3 lb
Released Time Test	< 1 Sec	< 1 Sec
Environment Temperature Range	-60 to 160 °F	-60 to 160 °F

Manufacturing:

The steel cores were manufactured on the lathe in Mustang 60.

The copper coils were wound by hand.

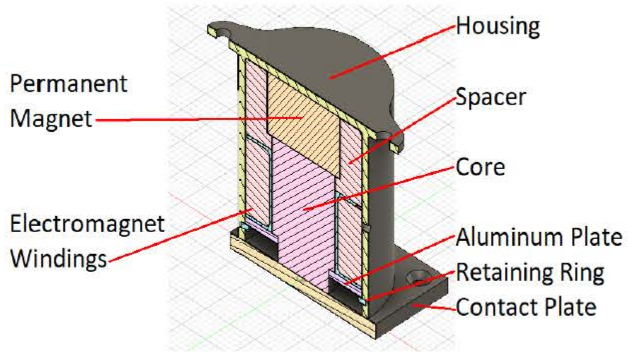
The outer cases were outsourced to Mustang 60's CNC shop.

The bobbins and spacers were 3D printed in mustang 60.

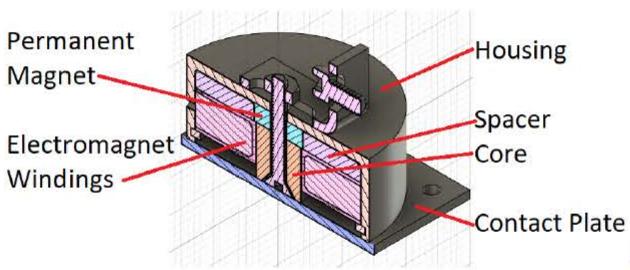
The thermal mass was manufactured on the lathe in Mustang 60.

The aluminum plates were manufactured on the water jet in Mustang 60.

Final Design:



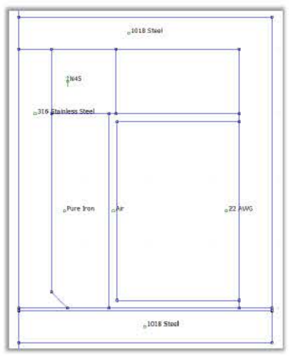
Discrete System Uplock



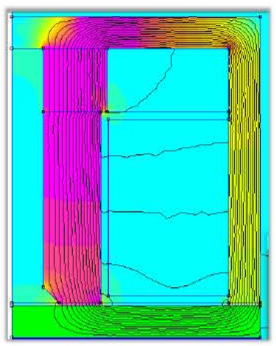
Distributed System Uplock

Analysis:

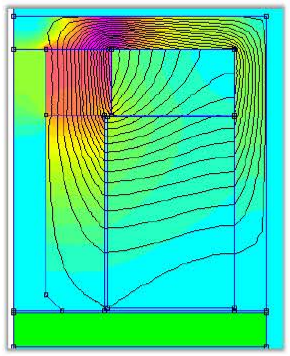
FEMM (Finite Element Method Magnetics)



Defining geometry and material properties.
The simulation was set up using MATLAB and then analyzed using FEMM. This allowed the geometry and material properties to be easily changed during the design phase.



Unpowered system FEMM results.
When unpowered a large amount of magnetic flux flows though the contact plate which results in a large magnetic force between the plate and the magnet system.



Powered system FEMM results.
As the electromagnet is powered on the magnetic field is redirected such that there is very little magnetic flux flowing through the contact plate.

Testing and Results:

Test	Action	Discrete System Results	Distributed System Results
Unpowered Hold Force (Fig. a)	Test force required to release systems in hold unpowered position.	Average Hold Force: 118.7lb	Average Hold Force: 26.4lb
Powered Hold Force	Test for minimum load required to release systems in hold position when powered.	Powered Hold Force: <0.615lb at 12.3A	Powered Hold Force: <0.425lb at 9.8A
Release Time (Fig. b)	Test time required for systems to release when powered.	Primary Coil: 0.050s; Secondary Coil: 0.050s	Primary Coil: 0.0470s; Secondary Coil: 0.0430s
Environmental Chamber	Test hold and release capability at high and low temperature limit.	Held unpowered at -65.2°F and 159.8°F. Released with a 23lb load with 9.75A at -65.2°F and 9A at 159.8°F.	Held unpowered at -65.2°F and 159.8°F. Released with a 5lb load with 6.75A at -65.2°F and 6A at 159.8°F.

(Fig. a)

(Fig. b)

Conclusion and Recommendations:

- Both systems passed all tests except discrete system did not pass unpowered hold force test.
- Improve discrete system to pass unpowered hold force test.
- Both systems were significantly heavier than our sponsors hoped. Permanent magnets are very heavy relative to the force they can hold.

Mechanical Engineering CAL POLY

Acknowledgements:
Dr. Eileen Rossman
Dr. Peter Schuster
Grant Boeckmann
Styx and Stones Senior Project Team

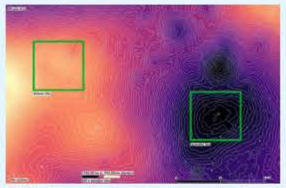
NASA's Break the Ice Lunar Challenge

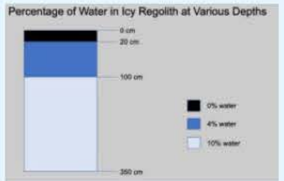
Vy Han, Alex Lewis, Peter Karkos, Eva Kouyate

NASA Centennial Challenges

Background

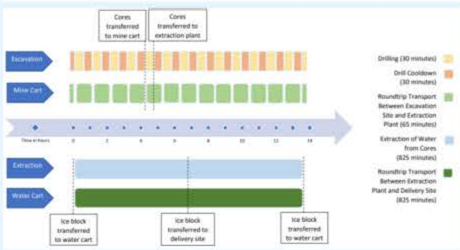
- The mission set by NASA is to extract water from icy regolith
- The regolith is located at the excavation site and must be transported to the delivery site
- The goal of this mission is to design autonomous system that can provide water over the course of the year

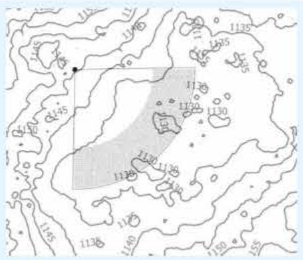




Analysis

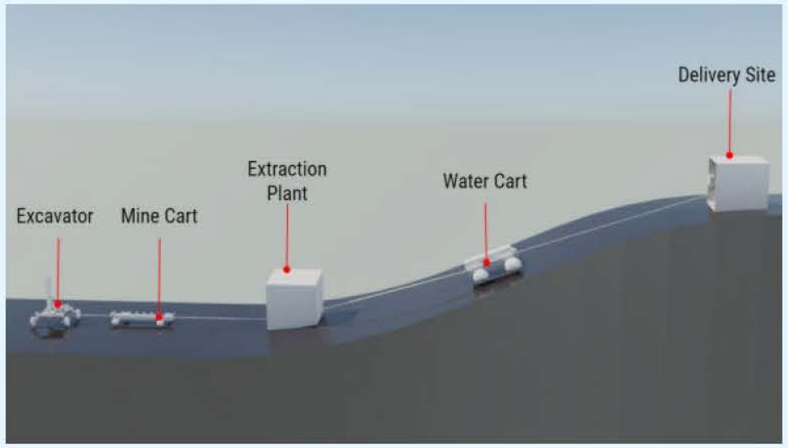
Performance Measure	Value Obtained	Requirement	Pass/Fail
Total landed mass	9,150 kg	Less than maximum (12,000 kg)?	Pass
Mass of water delivered	46.9 metric tons	More than minimum (10,000 kg)?	Pass
Maximum power used	6.31 kW	Less than maximum (10 kW)?	Pass
Average power used	5.16 kW		
Total energy used	1.63E8 kJ		
Ratio of total water delivered to total landed mass	5.13		

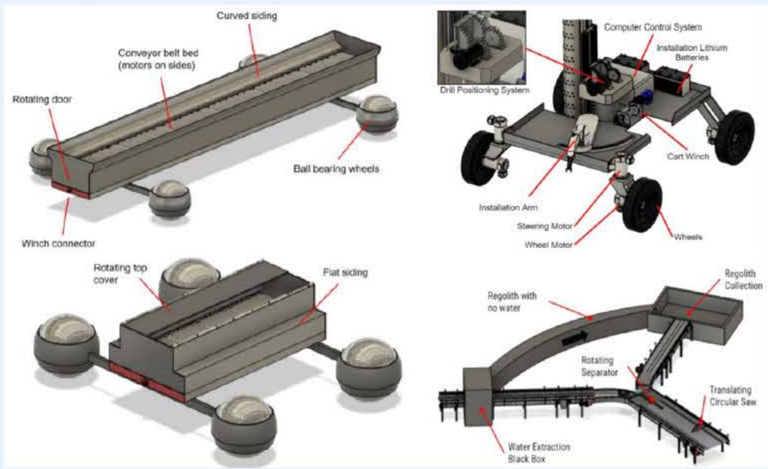




- We optimized the timing of the drilling, transport, and extraction processes to maximize the water output
- We created an excavation plan for drilling each hole throughout the year
- We surpassed NASA's goal of recovering 10,000 kg of water in a year

Final System Design



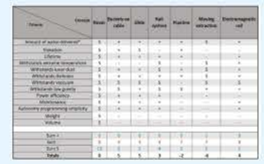


The autonomous system is composed of:

- An excavator for system set up and excavation of the regolith
- A mine cart to transport the regolith
- An extraction plant to extract water from the regolith
- A water cart to transport ice blocks to the delivery site

Design Process

- After ideating multiple excavation methods, we decided to talk with an engineer with the U.S. ice drilling program
- We used decision matrices to select our design direction



Manufacturing & Testing

- We tested our wheel concept using 3D printing wheels
- The concept was successful on concrete but did not work on sand

Conclusion

- Future testing could be done with more accurate lunar conditions
- This system could help sustain life on the Moon by providing water

Optimized Tip Cooling Using AM Process

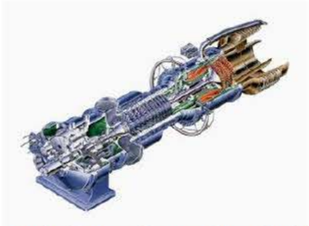
Team W14: Lourdes Sarmiento Martinez, Andy Van Bogelen, Alberto H. Gamez

SPONSOR
Solar Turbines
A Caterpillar Company

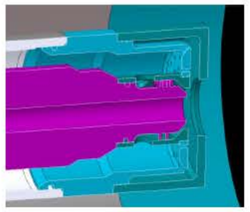
Rick Rogers
Rogers_Richard@solarturbines.com

PROBLEM

Historically Solar has used an expensive multi material solution to Fuel Injector Tip cooling. Typically, a Haynes 188 part has been EB welded to a 316L intermediate part. This process involves multiple manufacturing steps and limits the service life of the injector.



Gas-Only Power Generation Turbine (T60)

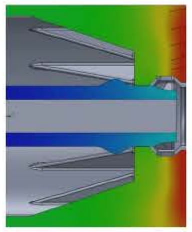


Existing Injector Tip Design

OBJECTIVE

Design:
- Injector tip
- Additive Manufacturing (AM) and service life required

Validation:
- AM test print using plastic and metal
- FEA, CFD
- Comparative heat dissipation testing

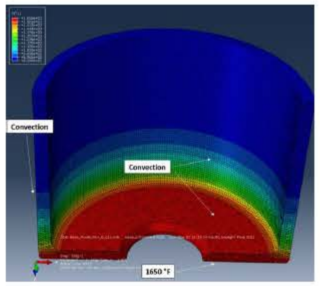


CFD Model

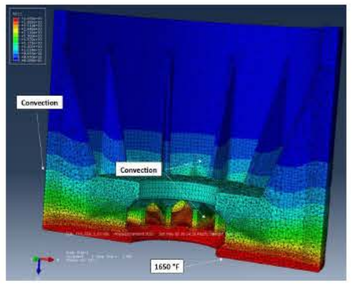
Concept prototypes 3-D printed w/ PLA

ANALYSIS

- Conducted Finite Element Analysis (FEA) comparison simulation test between Current Design/ Base Model and Fin Design using ABAQUS
- Conducted Computational Fluid Dynamics (CFD) comparison simulation test between Current Design/Base Model and Fin Design using SolidWorks
- Validated Fin Design dissipates more heat, allowing a 100-200 °F improvement at the inner face due to its complex AM compliant geometry.



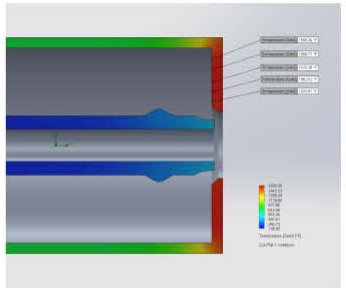
Current Design/ Base Model
Cross- Section FEA
$T_{Inner\text{-}face}$=1614 °F (ΔT=36 °F)



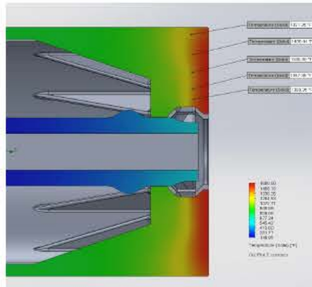
Our Fin Design
Cross- Section FEA
$T_{Inner\text{-}face}$= 1548 °F (ΔT= 102 °F)

	Model	Δ°F	% ↓
FEA	New	102	6.2
	Existing	38	2.2
CFD	New	288	17.5
	Existing	87	5.2

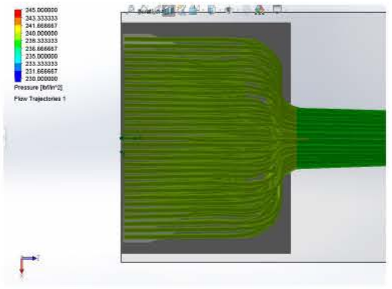
Summary Table



Current Design/ Base Model
Temperature Contour CFD
$T_{Inner\text{-}face}$=1562 °F (ΔT= 87 °F)

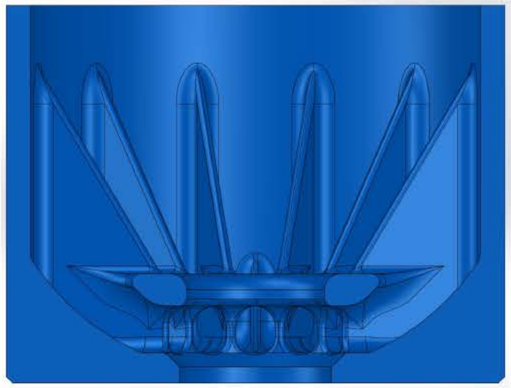


Our Fin Design
Temperature Contour CFD
$T_{Inner\text{-}face}$=1362 °F (ΔT= 288 °F)

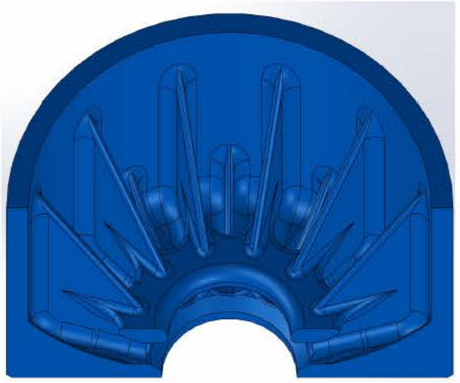


Passed Pressure drop Requirement
Pressure Streamlines
Fin Design CFD

FINAL INJECTOR TIP DESIGN



Cross-sectional view of the final design using fin structures to dissipate heat from the tip.



Cross-section angled view depicts the horizontal structure supporting a pilot tube and airflow channels between fins.

An PLA 3D printed structural prototype of an initial design was produced to verify the viability of producing this structure with metal Additive Manufacturing.

MANUFACTURING

- 3D Verification Print
  - Material: PLA
  - Printed by Innovation Sandbox
- Aluminum Test Prototype
  - Built in Mustang 60
  - Aluminum sheet, Conductive metal cement
- Full scale Test Prototype
  - Printed by Solar Turbines, On-Site
  - Material: Alloy X

Manufacturing Disclaimer: The original verification prototype planned for a stainless-steel additive manufacturing print at Cal Poly. Due to unforeseen machine failure and Covid, less precise models were constructed at the Mustang 60 shop.

TESTING/VERIFICATION

Test Component	Component Purpose	Simulation Property
Computer Fan	Forced Convection Source	Turbine Air Discharge
Reptile heat lamp	Radiation Heat Source	Fuel Combustion
Aluminum Fin model	Verification Prototype	Prototype Injector
Aluminum Flat Plate Model	Control Group	Existing Injector

Heat Dissipation Test Set-up
We used thermocouples, voltage-controlled fan, and a radiation lamp. The fin Design showed a 2 ° F drop temperature compared to the flat-plate.

CONCLUSION

Ideation and prototyping led the team to pursue 3 main design paths to accomplish the service life goals set by Solar Turbines. After FEA and CFD simulations assessing the heat dissipation qualities of the designs, a decision to further pursue and optimize a Fin Design was made. Further iteration and simulation predicted the Fin Design could potentially achieve the goal of a 1350 °F temperature threshold, or about a 150-250 °F comparative drop in temperature.

Due to complications with Covid-19 within the team and the Cal Poly metal AM machine break down, hand-crafted Aluminum versions of the current design and fin design were made. Although crude representations of the actual injector tips, these mock-up heat sink parts were used to perform a version of our planned heat dissipation test. Using a radiation heat source and voltage-controlled fan for airflow, the temperatures at different points on each model were measured using thermocouples. The fin structure showed a decrease of about 2 °F throughout the injector; thus, verifying that heat fins help dissipate heat through its geometry.

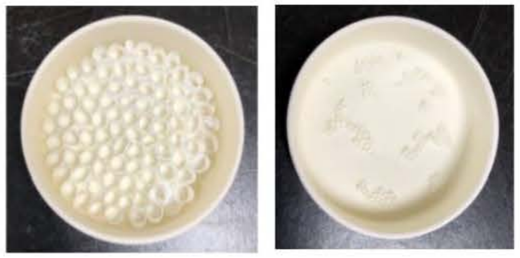
Optimizing Mini-Tubular-Ceramic Production

Daniel Freeman, Leo Taranta Slack, Hunter Brooks

This project would not have been possible without the help of Prof Eileen Rossman and Dr. Hans Mayer

Project Sponsored by:
Lawrence Livermore National Laboratory
Dr. James Kelly, Mr. Michael Ross

Scientists at Lawrence Livermore National Labs (LLNL) are researching new filter technology that utilizes Mini-Tubular-Ceramics (MTC's). MTC's are placed inside a large cylinder, disrupting airflow through the cylinder and helping clean the air. MTC's are made from an electrospun nanofiber ceramic mesh which is first peeled from a backing before being formed into small rings. These rings are then heat treated, causing them to shrink 60x volumetrically. The goal of this project was to increase the rate of production of the MTC's, enabling more thorough tests to be performed.



Left: Finished MTC. Right: Post heat-treated MTC

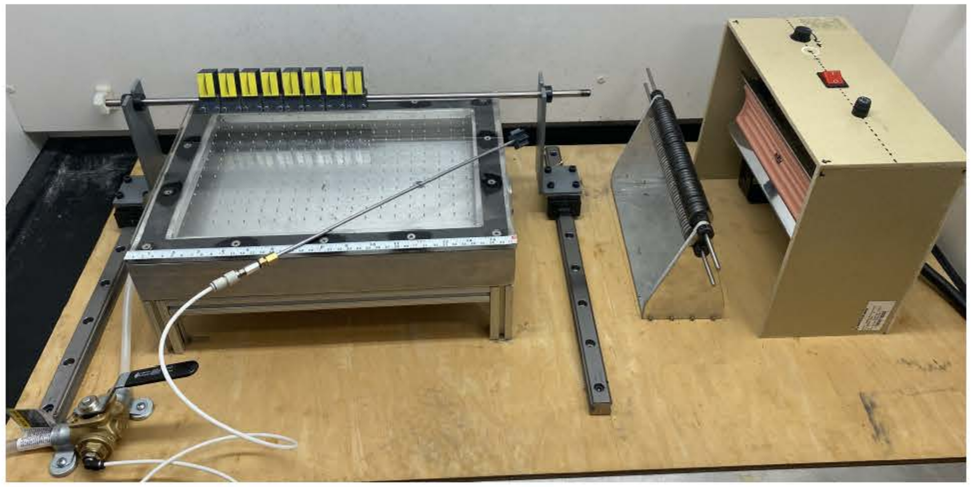
This project is a continuation of a previous Cal Poly senior project. We began by analyzing their design, figuring out what worked and what didn't. We decided to keep the existing vacuum table (used to peel the backing off the mesh) and rework the cutting, rolling and sealing mechanisms.

The mesh is cut into long strips using our primary cutter. The design is like a paper cutter, however fixed blades proved to deform the material. This was solved by using rotating blades. The idea of rotary cutting blades comes from a pizza cutter – there is no warping of the material due to a continuously changing point of contact with the material.

Keep clear for support

The vacuum mandrel is designed to pick the peeled mesh up off the table and roll it into a cylinder of a specified diameter. Coated with Teflon and featuring a 3D printed removable end cap, the mandrel is designed so operators can easily place finished MTC's in a crucible for heat treatment.

Like the primary cutter, the secondary cutter features rotary blades to cut tangentially. The secondary cutter however serves the dual purpose of sealing the disks. A ceramic heater provides radiative heat to several sealing disks on the secondary cutter assembly, which creates a sealed 'band' around the circumference of the MTC.



Final MTC production assembly featuring vacuum table, vacuum mandrel, primary cutter, secondary cutter, heater, electrical infrastructure and pump.

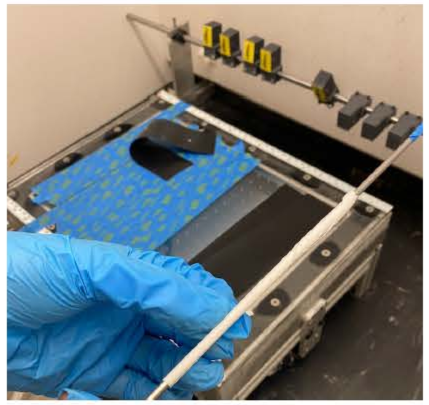
Aluminum was used for most components, which we cut using the Mustang 60 water jet. Our blade holders are 3D printed, meaning that they can be quickly and cheaply made if wear occurs. The heater box features fiberglass for safety and insulation.

Left: Printed blade holders. Center: Mandrel manufacturing.
Right: Waterjet-cut sealing disks

Leave two 1.5 x 3 inch spaces blank at the bottom for the poster stands. DON'T mark these boxes on your poster, though! You can position these spaces anywhere on the bottom – just make sure it will be stable.

The mandrel was made using an aluminum jig, which allowed for 1/16" diameter holes to be drilled in sequence using a microchuck and pillar drill. Both the pump and heater were wired to standards conforming with LLNL and Cal Poly. The entire assembly is mounted to a plywood base for ease of transport and maintaining relative position between subassemblies.

Testing was performed in the Cal Poly Material Engineering fume hood, due to the hazards associated with the nanofiber mesh. We first tested our process on functional prototypes before measuring the abilities of our final product.



Testing in the MATE lab

We are very proud of the work we have accomplished during this senior project, and very grateful for everyone who helped us along the way. This final prototype will help our sponsors refine the specifications of the material. Our machine was designed with scalability in mind – you can imagine several of these machines, automated with actuators, such as motors, creating millions of MTC's. We hope that the concept of our manufacturing process will live on when MTC's become mass produced.

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W15 - Mug for Veterans with Hand Tremors

Team: Eliot Briefer, Nicholas Greco, Tiernan Kehoe, Lucas Martos-Repath
Advisor: Professor Eileen Rossman

Mechanical Engineering, Cal Poly

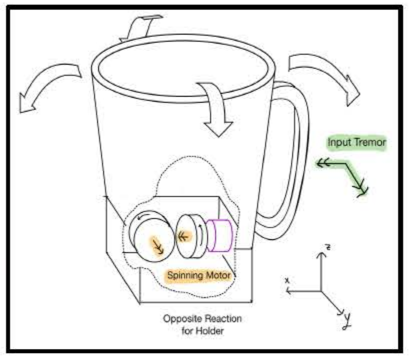
Sponsored by:
Cal Poly TECHE &
Melissa Oliver
McGuire VA Medical Center

Problem Description:

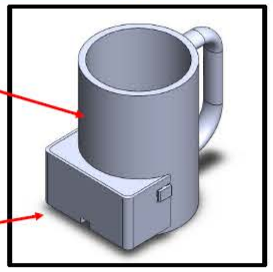
Veterans with hand tremors can have a difficult time drinking from open-top containers. Tremors can cause liquid to spill during the act of drinking leaving users frustrated. Veterans need a device that is lightweight, aesthetic, can adjust to various tremors, and can be operated in multiple planes to allow the veterans full control over the device.

Conceptual Idea: Reaction Wheels

Motors in the electronics puck accelerate and decelerate reaction wheels to generate torque and counteract input torques from the hand tremors. All electronics are contained to create a more standard appearance



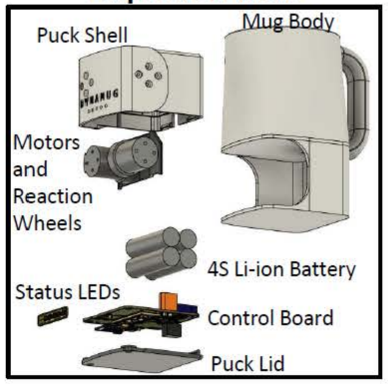
Initial Design:



- All electronics enclosed in removable puck for easy cleaning
- Cylindrical mug body
- Electronics puck protrudes from mug to fit reaction wheels
- Small battery due to size constraints (650 mAH)
- No battery protection or monitoring
- Spring loaded latch mechanism to hold electronics puck in place.
- IMU measures tremor for closed loop feedback

Final Prototype:

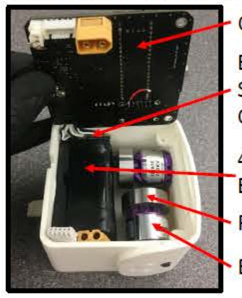
Exploded View



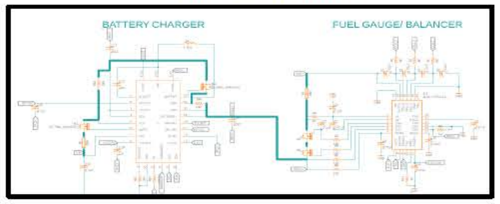
- Square mug base is more aesthetically pleasing for users and allows for a larger battery (2100 mAh)
- Two reaction wheels for counteracting tremors in two axes
- Battery management and protection system (BMS)
- Status LEDs indicate battery state of charge
- Custom control board distributes power and communication.
- Compliant latch mechanism reduces component count, complexity and cost

Nylon Powder Print

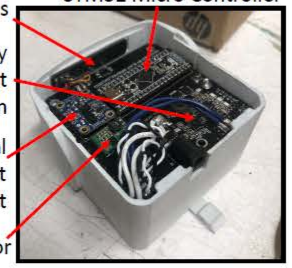
Inside The Electronics Puck



BMS Schematic



Control Board Layout



Analysis and Dynamic Modeling:

One Axis Tremor Model

$$M_{tremor}(t) = M_{max} \sin 2\pi f t$$

Tremor Amplitude

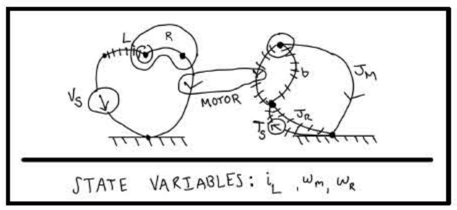
$$M_{max} = \frac{1}{3} f^2 m \theta_{max} \pi^2 (0.75D^2 + H^2)$$

- D, H, and m are mug parameters.
- θ_{max} is tremor amplitude in radians
- f is tremor frequency.

Initial Motor and Reaction Wheel Sizing Methodology

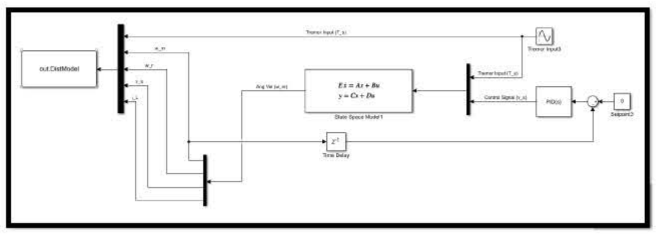
Model a one axis tremor as a sinusoidal moment applied to the mug. Size the motors and reaction wheels so that they can generate at least M_{max} torque and absorb the impulse of a full tremor cycle without saturating.

System Dynamics Linear Graph, Normal Tree, and Block Diagram

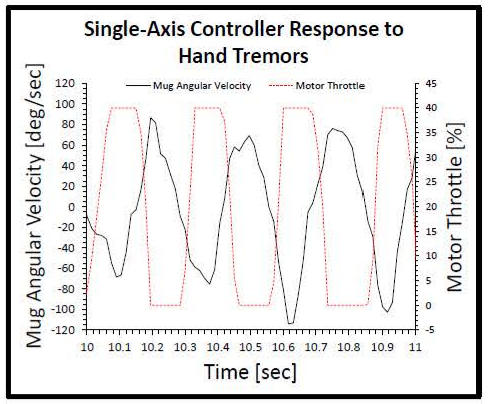


The System dynamics normal tree was used to develop a state space model for designing and testing the closed loop controller in MATLAB and Simulink

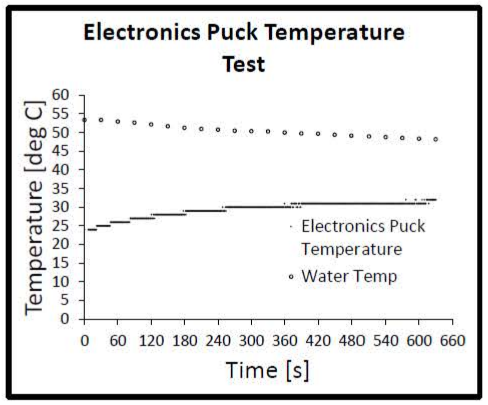
State Space Block Diagram used for design of full state controller



Test Results:



- A tremor was simulated by shaking the mug by hand with the controller response shown.
- The test shows that the IMU's ability to measure to tremors in real time is sufficient to counteract the tremor.

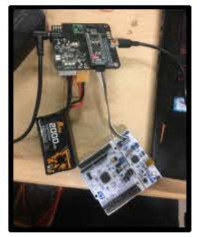


- The operating temperature of the electronics puck must be carefully maintained for safe mug operation.
- The plot shows an appreciable but not concerning increase of the puck's temperature for a safe-to-consume, hot liquid

Note: Additional performance testing is ongoing due to re-manufacturing delays.

Manufacturing:

Wiring Electronics



Machining Reaction Wheels

3D Printing Mug Shell

- Electronics puck and mug shell 3D printed in house
- Reaction wheels machined in-house
- PCB manufactured by JLCPCB, assembled in house.

Recommendations:

- Implement field-oriented motor control by using a sensored ESC to reduce noise and improve low rpm response time.
- Add a snubbing capacitor at the charge port to eliminate voltage overshoot when hot plugging.
- Custom motors to increase rotational inertia and reduce electronics puck size.

W24: Produce Sorting Aid

Jessie Boucher ○ Teng Lee ○ Annica Navarro ○ Natalie Roberts
Fall 2021
Mechanical Engineering CAL POLY
ALAMEDA COUNTY COMMUNITY FOOD BANK
Sponsors: Leif Magnuson & Marcos Trujillo

Background

- Local distribution center provides produce, meat, and other food to community members.
- Some produce comes in pallets of 50 lbf bags.
- Leif Magnuson's wooden prototype.

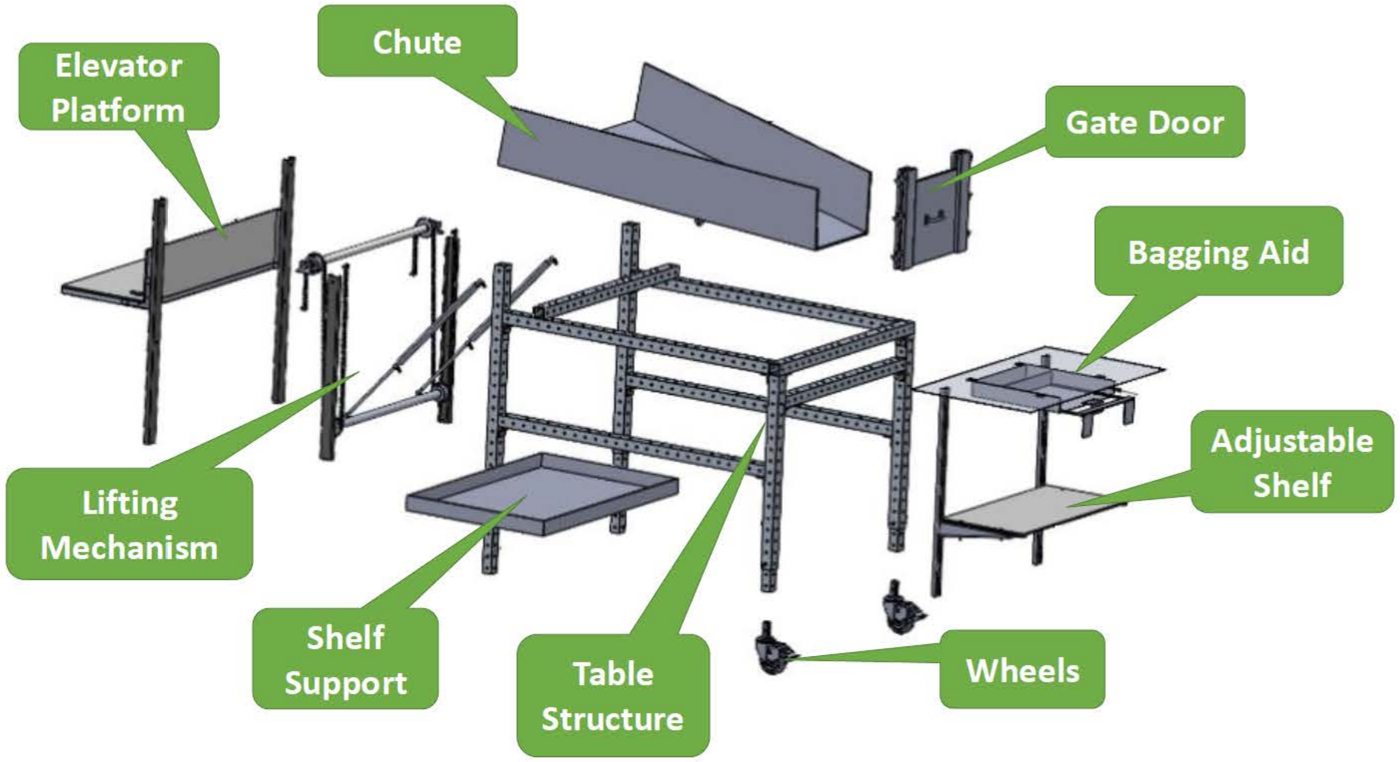

Current Issues:

- Volunteers under excess strain from manually lifting heavy produce.
- Too many operations for one user.

Project Scope

Design a mechanism that is ergonomic, time efficient, and safe for the volunteers to lift heavy produce and distribute the produce into bags ready for individuals to receive.

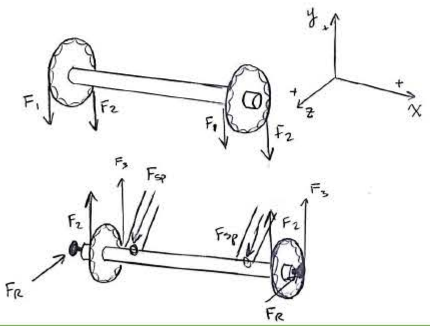
Final Design



Design Process

- Prototyping


- Force analysis for lifting mechanism and gas spring sizing
- Stress analysis for shaft sizing



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Manufacturing

- TIG Welding
- Turning/facing
- Milling
- Drilling
- Sanding
- Chopping
- Water Jet


Elevator Platform Support

Water Jet Cutting Adjustable L bar Cubby

Testing

- Strength
- Operation Time
- Intuitiveness
- Input Force
- Mobility
- Chute Friction
- Durability





Results

- Strength: helps lift and contain 50 lbf produce bag
- Operation Time: 11.29 s
- Intuitiveness: (13/15 pass)
- Lifting Mechanism Upward Input Force: max initial input of 30.6 lbf to average 25.0 lbf continuous
- Mobility: move more & locks
- Chute Friction: 0.22 ± 0.04 lbf produce movement
- Durability: Pass, 0 deformations

Next Steps:

Our sponsors plan to produce multiple copies of our design soon for other foodbanks.

Keep clear for support

Acknowledgements:

- Advisor Eileen Rossman
- Kevin Williams
- Dr. Joseph Mello
- Eric Pulse
- Shop Techs at Cal Poly Mustang '60
- Team W22 Door Uplock Team