Malcolm LeClair
Engineering Portfolio

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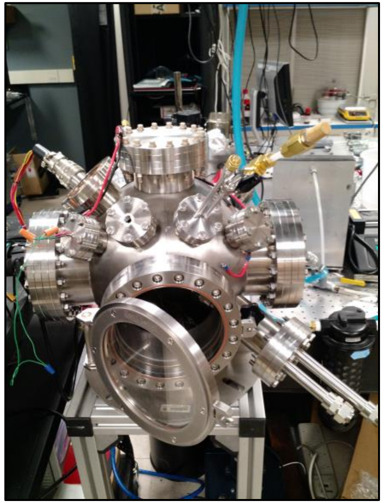

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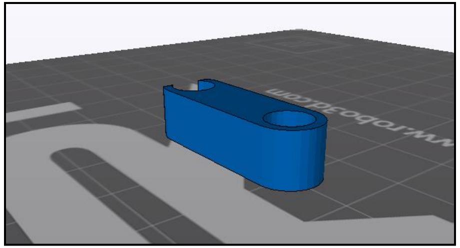
3D Printer

Fall 2016

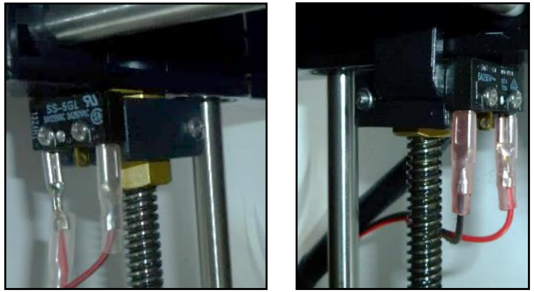
Robo3D R1+ Upgrades

- **Goals:** Upgrade Printer with network connectivity and
  remote monitoring capability
  Add supports for Z-Axis guides & filament holder
- **Octoprint:** Installed Octoprint server for remote access and printing over the local area network, and configured router & port forwarding for internet access
- **Webcam:** Configured webcam & drivers with mjpeg-streamer
- **Upgraded Parts:** Wiring through-hole cover
  Spool Holder
  Z-axis Stabilizer



Robo3D R1+ Repairs

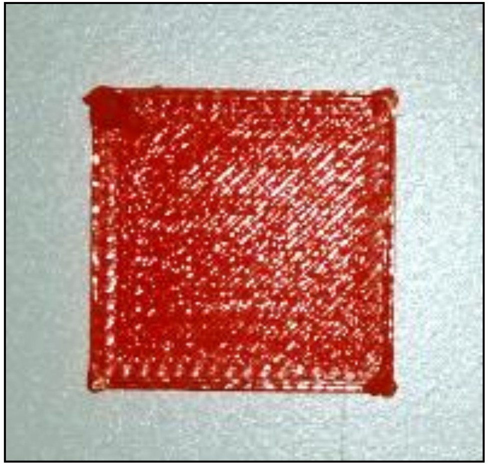
Z Axis Alignment



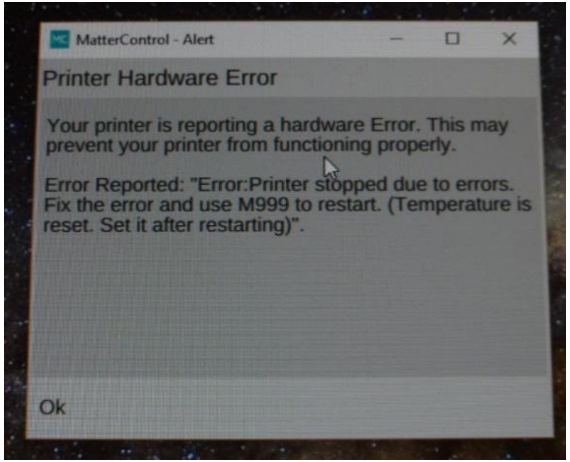
Incorrect Correct

- **Goal:** Restore printer to working order
- **Initial Issues:**
  - Z axis misalignment
  - Prints cutoff at seemingly random points
  - Filament drips through extruder
- **Solutions:**
  - **Z Axis –** Disassemble printer, reinstall and level Z axis
  - **Early Abort –** Error codes traced back to low temperature readings in extruder. Thermistor was inspected, found to be faulty and replaced
- **Next Step:**
  - **Dripping –** Adjust extruder temperature to minimize dripping
    Write custom bridge G Code to retract filament when traversing the build platform

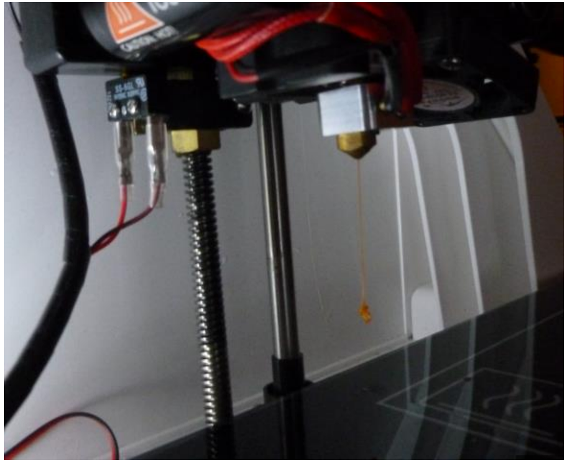
Robo3D R1+ Repairs



An unsuccessful print after low temp cutoff



Extruder temperature errors



Dripping extruder hotend

Skills Learned

- Port Forwarding
- Linux networking settings
- Basic G-Code commands
- 3D Printing design, mechanics, maintenance and limitations
- Error message debugging
- MatterControl 3D printer software

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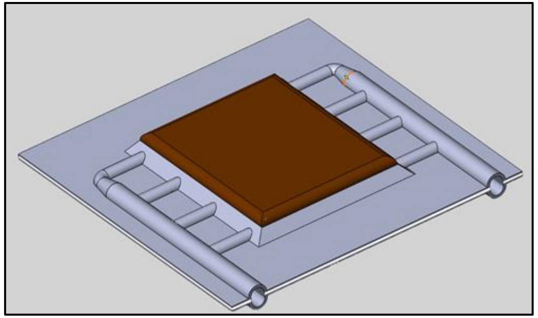
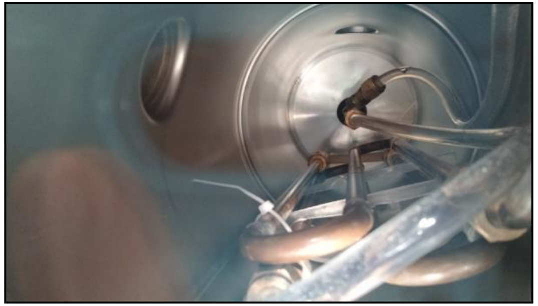
MultiScale Thermal Fluids Lab

Fall 2014 - Fall 2016





Evaporator render courtesy
Dr. Carlos Rios

- **Project:** Design an evaporator for Advanced Thermal Battey
- **Background:** Thermal batteries exchange the typical compression cycle for an adsorption cycle and hold the potential to remove the draw of HVAC on Electric Car batteries yielding a potential range increase of 30%

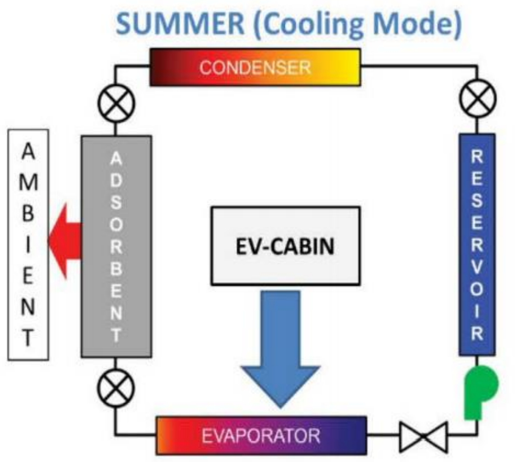
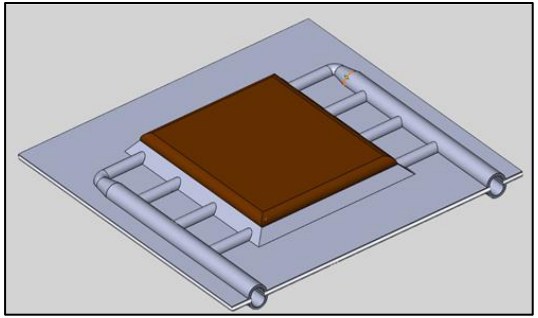


Diagram shows how the thermal battery system works in summer. Arrows show heat transfer direction. (MIT)

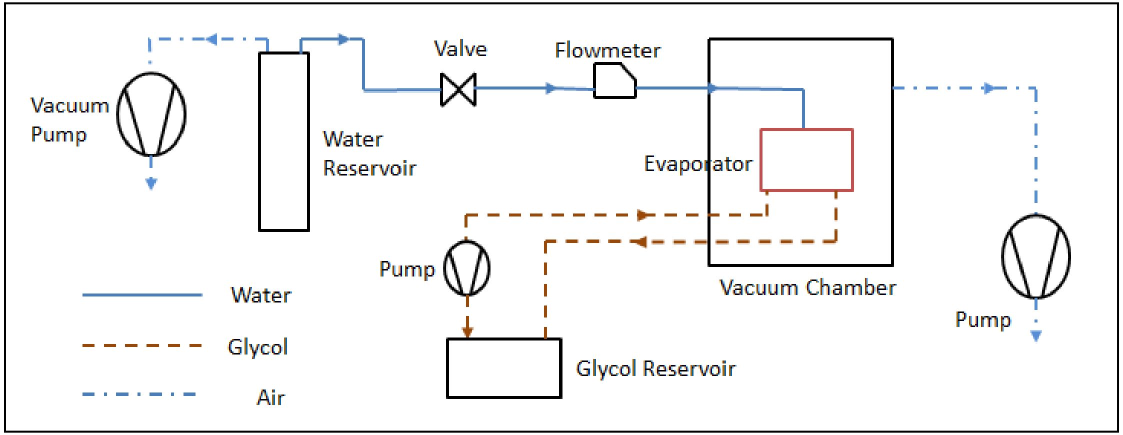
Porous Media Evaporation – 1st Iteration

- **Design Concept:** Use porous sintered copper as a medium for a pressure drop to induce evaporation of a water source at low pressures with a flowing glycol heat source
- **Experimental Design Role:**
  - Identified critical temperature measurements
  - Created LabView data collection programs
  - Calibrated flowmeters in uL/min range for accurate heat transfer calculations
  - Developed protocols for system control and collected data to characterize thermal properties



Glycol heated evaporator render courtesy
Dr. Carlos Rios

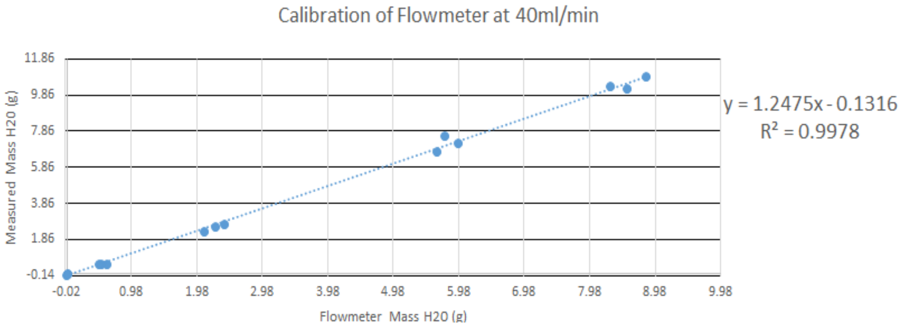
Experimental Set-Up

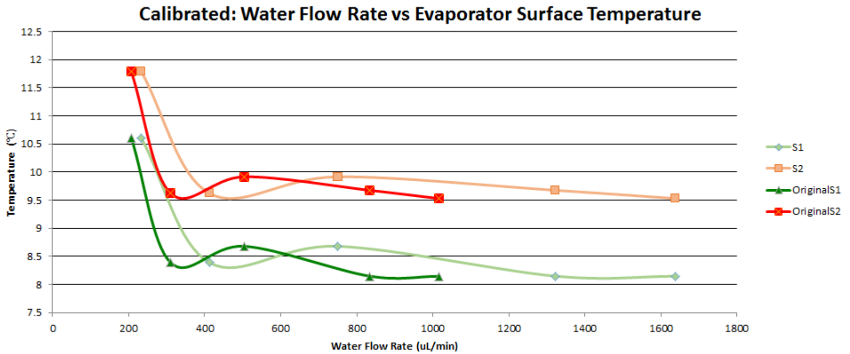


Test Conditions

- Chamber Pressure – 760 Pa
- Evaporator Temperature – 3-10°C
- Water Flow Rate – 0-1000$\frac{\mu L}{min}$
- Glycol Flow Rate – 100-1500$\frac{mL}{min}$

Calibration Curves & Effect on Data





Porous Media Evaporation – 2nd Iteration

◈**Challenges of previous design:**

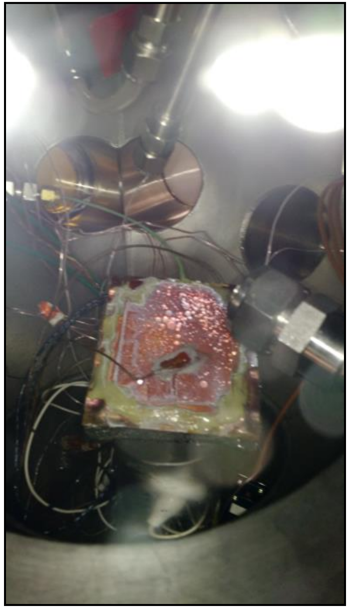
ΔP between coolant line and vacuum chamber leads to deformation of the copper shell damaging the porous media

◈**Design Concept:** Remove the pressure drop by using a half shell evaporator and an electric heat source

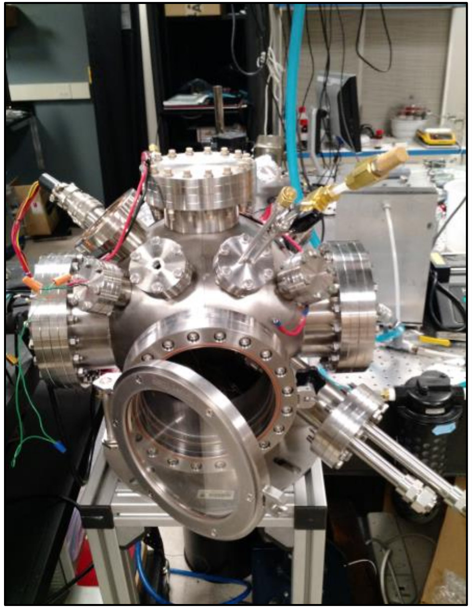
◈**Design Role:**

- Sourced components
- Designed circuit to measure instantaneous power output
- Fabricated new evaporator for tests with electric heat source

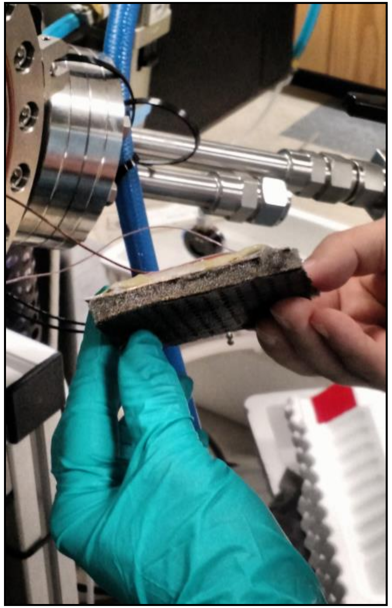
Half shell evaporator render courtesy Dr. Carlos Rios



Evaporator with PTFE coating saturated during test



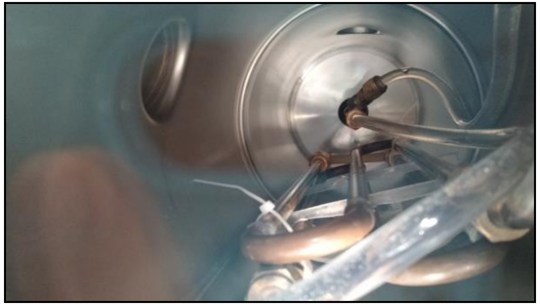
Vacuum chamber configured for test with electric heat source



Evaporator with electric heat source

Issues Observed:

- Heat buildup due to air gap between heating element and porous media
- Water flow rate instability
  - -Chugging
  - -Saturation

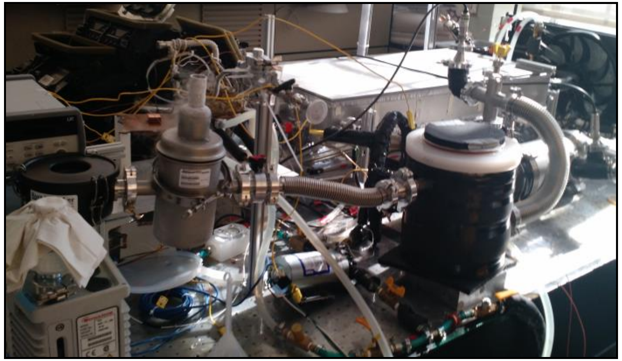


Copper Pipe – 3rd Iteration

◈**Challenges of previous design**: System instability, delays to system integration timeline

◈**Design Concept:** Simplify the evaporator to an easier to control, low pressure boiling heating coil at the cost of increased system weight

◈**Design Role:**



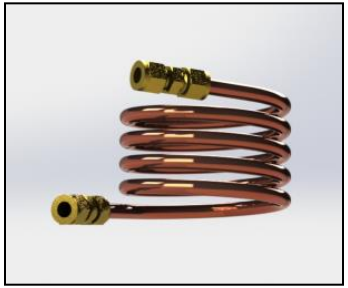
Sourced components for new vacuum chamber

Identified temperature measurements required to characterize heat flux and power dissipation through the system

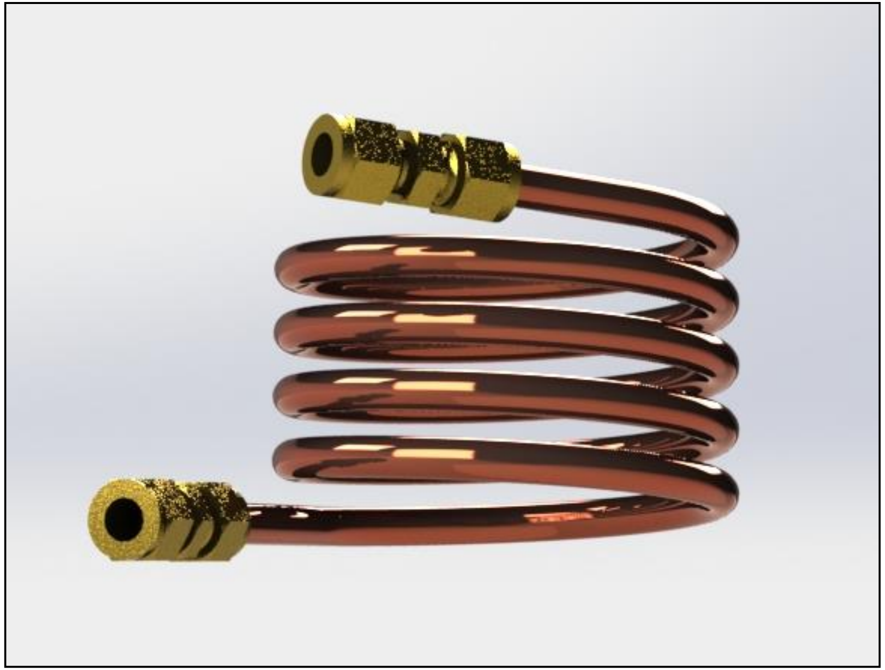
Characterized performance of various tube geometries by collecting and analyzing heat flux data

Low Pressure Boiling Experimentation Condenser Design

- **Design Goal:** Create a long term low pressure boiling testbed to probe the mechanics of boiling at pressures <1000Pa.
- **Constraints:**
  - System must be closed
  - Must fit within & interface with existing vacuum chamber
  - Low cost
  - Corrosion resistant
  - Must tolerate flow rates required to reach desired heat flux



- **Solution:**
  - Helically wrapped copper pipe ~1.5m long, 10cm Diameter, Swagelok fittings to interface with vacuum chamber



◈Testing and Validation:

Pressure Testing – The condenser was installed to the vacuum chamber and evaluated in an overnight vacuum hold test. No leaks were detected.

Skills Learned

- Basic fluid dynamics
- 3D Modeling and rendering
- Practical application of thermodynamics
- Experimental design & data collection
- Vacuum system design
- Material and sensor selection
- Design iteration
- Working inside a budget

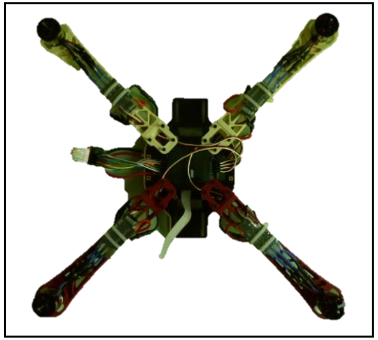
3

QuadCopter

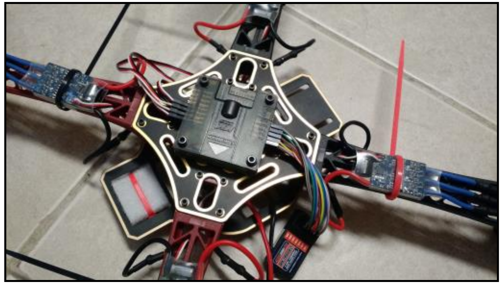
Spring 2016

hkk2.1	1	flight controller	$15.00	$15.00	http://www.amaz	Control
quadcopter frame	1	quadcopter fram	$15.99	$15.99	http://www.amaz	Quad
esc	4	combo	$15.90	$63.60	http://www.amaz	quad
motor	4	combo	$10.00	$40.00	http://www.amaz	quad
props	1	8x props	$8.99	$8.99	http://www.amaz	quad
battery	1	3000mah	$21.42	$21.42	http://www.amaz	quad
battery charger	1	battery charger	$32.07	$32.07	http://www.amaz	quad
prop nuts	1	5x prop nuts	$4.04	$4.04	http://www.amaz	quad
txrx	1	radio	$53.20	$53.20	http://www.amaz	quad

QuadCopter Design



- **Goal:** Build and test a quadcopter based on the HKK2.1 Flight Controller
- **Constraints:**
  - $300.00 budget
  - Maximize flight time
  - Create a modular system for future upgrades



- **Budgeting:**
  - Created a comprehensive budget for all requisite components
  - Left a buffer for incidental expenses
- **Assembly:**
  - Soldered & crimped quick disconnect connectors for easy replacement
  - Assembled frame, attached components
  - Configured & calibrated flight controller

Skills Learned

- Creating a bill of materials
- Completing a project under a budget
- Soldering
- PID tuning
- Flying a Quadcopter (A work in progress)