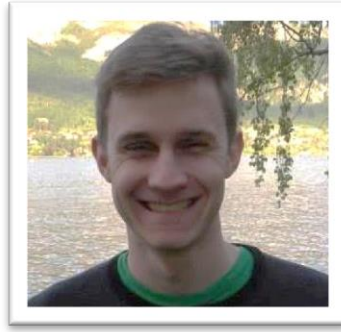




Malcolm LeClair
Engineering Portfolio



About Me

I'm a 3rd year Computer Engineering Major, Mechanical Engineering & Computer Science Minor at Northeastern University. I chose to study engineering because I love finding solutions to problems, learning how systems work and how they can be improved.

While I'm not in class, I enjoy running, rock climbing, and playing guitar

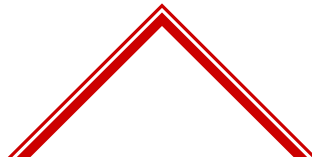


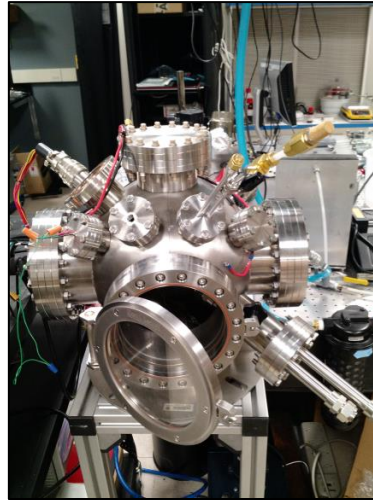


Table of Contents

1. 3D Printer



3. MultiScale Thermal Fluids Lab



2. QuadCopter





1

3D Printer

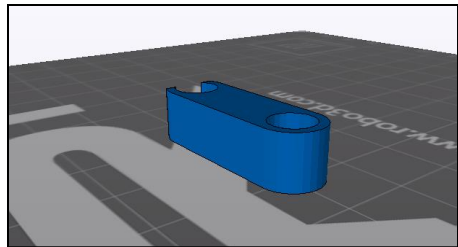
Fall 2016



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

◆ **Goal:** Restore printer to working order

◆ **Initial Issues:**

Z axis misalignment

Prints cutoff at seemingly random points

Filament drips through extruder

◆ **Solutions:**

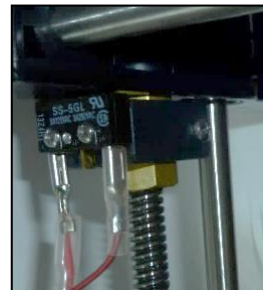
Z Axis – Disassemble printer, reinstall and level Z axis

Early Abort – Error codes traced back to low temperature readings in extruder. Thermistor was inspected, found to be faulty and replaced

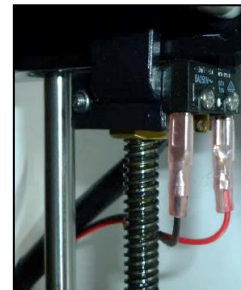
◆ **Next Step:**

Dripping – Adjust extruder temperature to minimize dripping
Write custom bridge G Code to retract filament when traversing the build platform

Z Axis Alignment



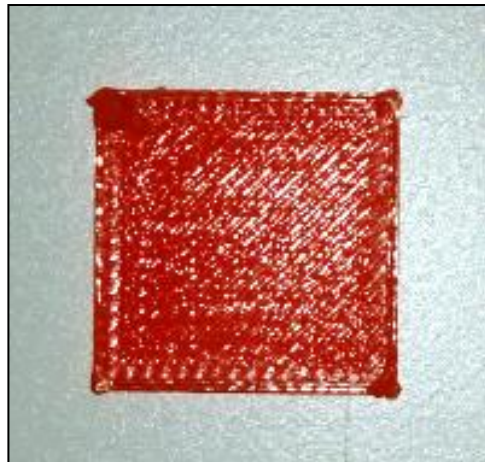
Incorrect



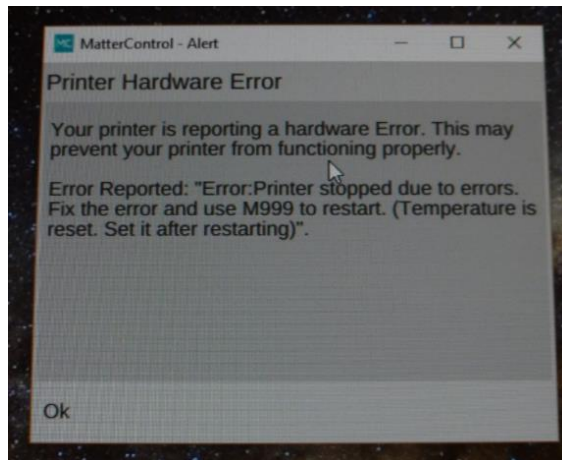
Correct



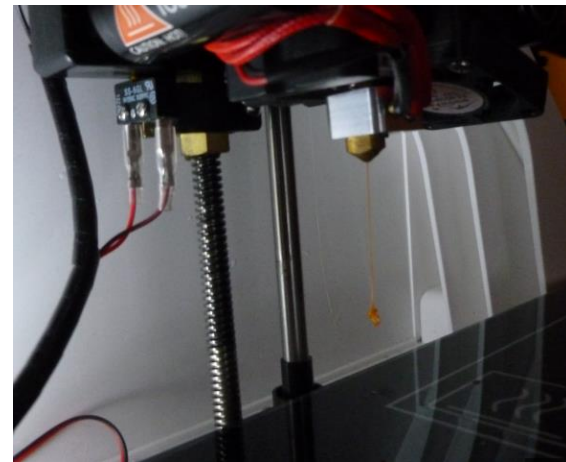
Robo3D R1+ Repairs



An unsuccessful print
after low temp cutoff



Extruder temperature
errors



Dripping extruder hotend



Skills Learned

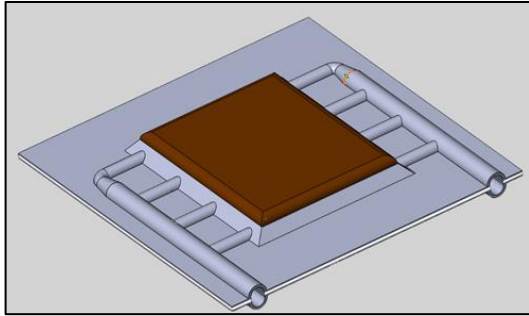
- ◆ Port Forwarding
- ◆ Linux networking settings
- ◆ Basic G-Code commands
- ◆ 3D Printing design, mechanics, maintenance and limitations
- ◆ Error message debugging
- ◆ MatterControl 3D printer software



2

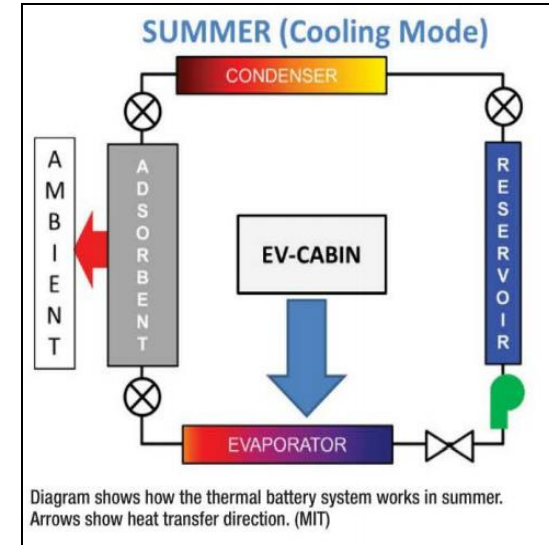
MultiScale Thermal Fluids Lab

Fall 2014 – Fall 2016



Evaporator render courtesy
Dr. Carlos Rios

- ◆ **Project:** Design an evaporator for Advanced Thermal Battery
- ◆ **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%



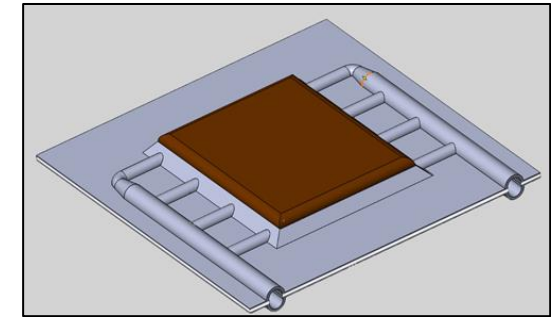


Porous Media Evaporation – 1st Iteration

♦ **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:**

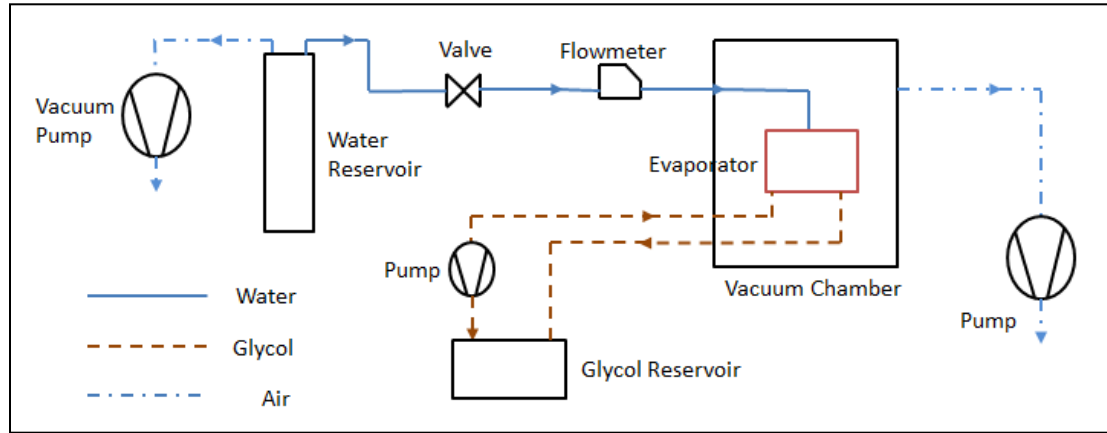
- Identified critical temperature measurements
- Created LabView data collection programs
- Calibrated flowmeters in $\mu\text{L}/\text{min}$ range for accurate heat transfer calculations
- Developed protocols for system control and collected data to characterize thermal properties



Glycol heated evaporator render
courtesy
Dr. Carlos Rios



Experimental Set-Up

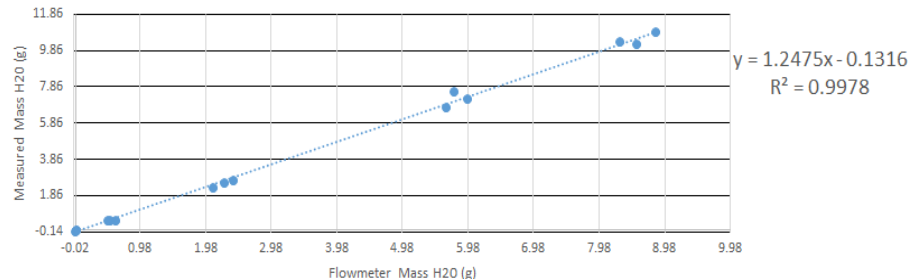


Test Conditions

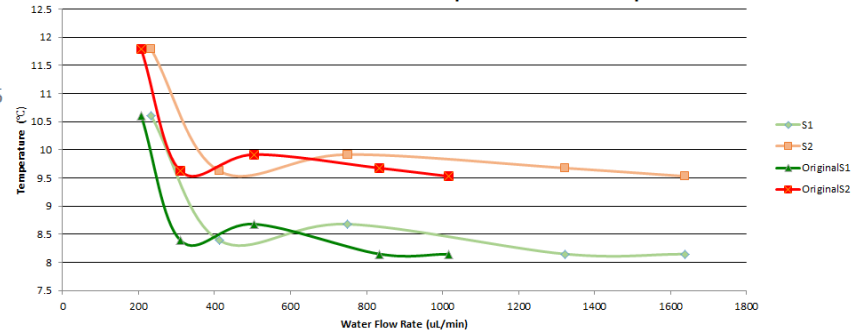
- Chamber Pressure – 760 Pa
- Evaporator Temperature – 3-10°C
- Water Flow Rate – 0-1000 $\frac{\mu\text{L}}{\text{min}}$
- Glycol Flow Rate – 100-1500 $\frac{\text{mL}}{\text{min}}$

Calibration Curves & Effect on Data

Calibration of Flowmeter at 40ml/min



Calibrated: Water Flow Rate vs Evaporator Surface Temperature





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

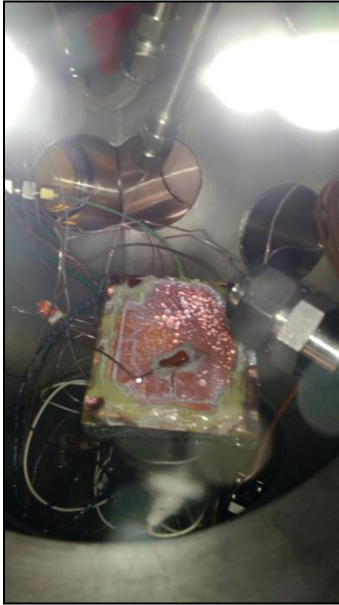
♦ **Design Concept:** Remove the pressure drop by using a half shell evaporator and an electric heat source

♦ **Design Role:**

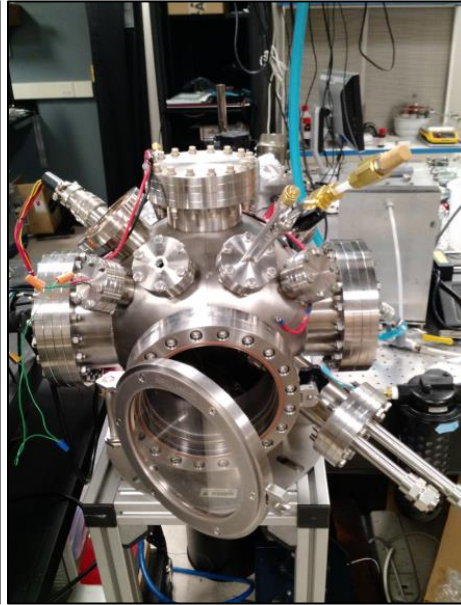
- Sourced components
- Designed circuit to measure instantaneous power output
- Fabricated new evaporator for tests with electric heat source



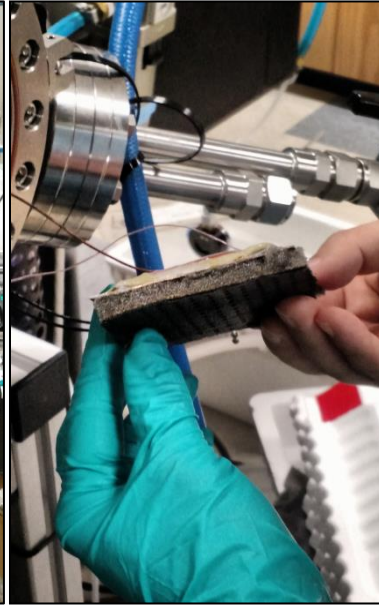
Half shell evaporator
render courtesy
Dr. Carlos Rios



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 $<1000\text{Pa}$.

♦ **Constraints:**

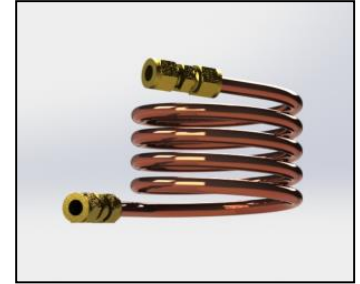
System must be closed

Must fit within & interface with existing vacuum chamber

Low cost

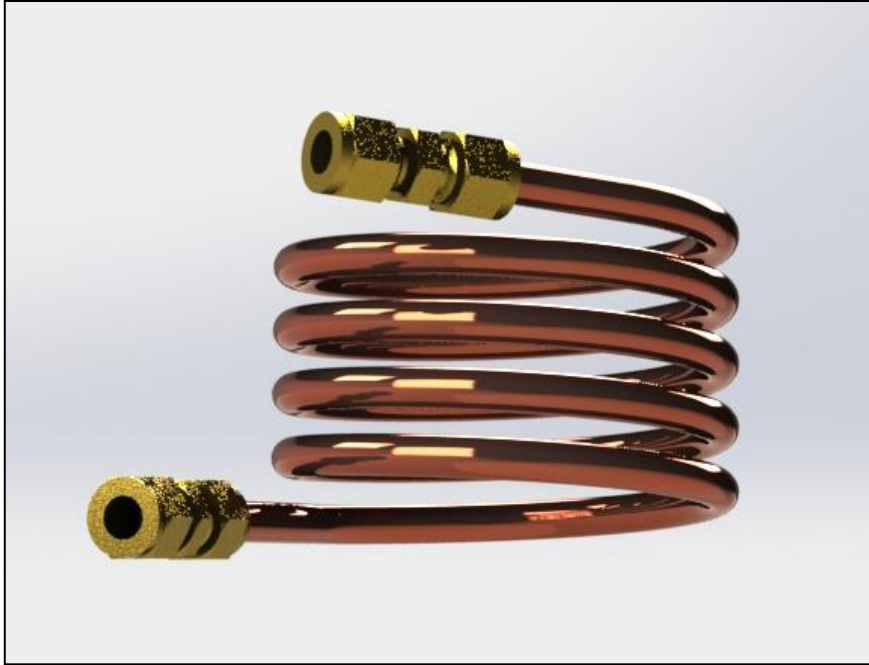
Corrosion resistant

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

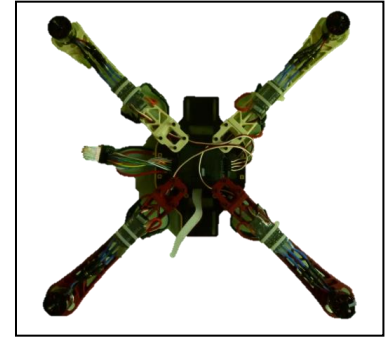
QuadCopter

Spring 2016

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

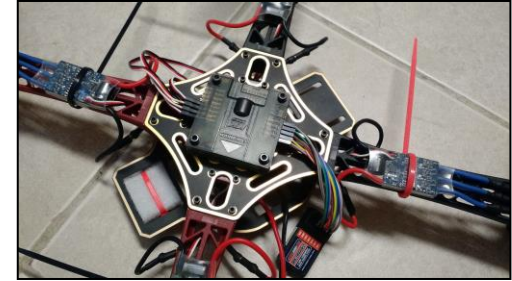
Left a buffer for incidental expenses

◆ **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)