PROTOTYPE MACHINE FOR COATING STABILIZED LITHIUM METAL POWDER
Interim Presentation

ME #16 / ECE #18

Sponsor: General Capacitor LLC (Harry Chen)

Advisor: Dr. Shih, Dr. Frank, & Dr.Zheng

Instructors: Dr. Gupta

Team Members:

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Overview

- Background
- Motivation
- Objective
- Current Methods
- Constraints
- Current Design
- Progress to Date
- Challenges/Lesson Learned
- Future Plans
- Budget
- Updated Schedule
- Questions/Comments

Background Information

- Sponsor
  - General Capacitor
    - Dr.Zheng, founder and Chief Scientist of General Capacitors, is our main technical advisors
- Product
  - Stabilized Lithium Metal Powder (SLMP)
    - Developed by FMC Lithium Corporation
      - Particle size: 30-60 Microns

Image 1: General Capacitors Logo

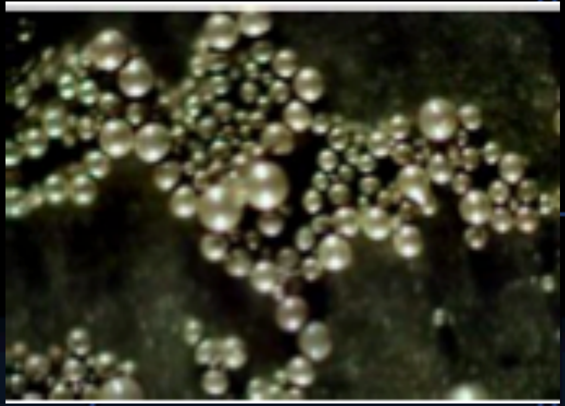


Image 2: SEM image of SLMP.

Background Information

- Lithium-ion Batteries
  - Rechargeable batteries
  - When the battery is in use, Lithium ions move from a negative electrode, also known as anode, to a positive electrode, or a cathode.
    - When they recharge the Lithium ions accumulated in the cathode flow back to the anode.
    - Anodes typically contain lithium compounds, while cathodes contain carbon compounds.

Motivation

- Experimentation conducted by FMC Lithium Corporation showed that the use of SLMP
  - Increases:
    - Battery capacity by 5% to 15%
    - Energy density by 2-4 times
    - Battery life
- SLMP can be applied onto pre-existing anodes
- Technology can used in batteries, cell phones and energy storage, such as super capacitors.

Objective

- To create a prototype machine that can coat SLMP.
  - Goal
    - To produce a uniform layer of SLMP onto pre-existing anodes
      - Minimum layer thickness of 150μm
  - Purpose
  - Our Approach
    - Dry dispersion method

Image 3: A photo of a hard Carbon Electrode.

Image 4: A photo of a hard carbon electrode applied with SLMP.

Current Methods Available

- FMC Lithium
- Method: Slurry application in which SLMP is mixed into a slurry using a volatile solvent.
  - After application of the slurry, the solvent evaporates and leaves a well distributed coat of SLMP.

Image 5: Photo from FMC Lithium conducting Slurry Application.

- Tokyo Electron Limited
- Method: Form a thin lithium film on anode sheet by melting and spraying lithium-containing powder.
  - Using argon gas to melt.

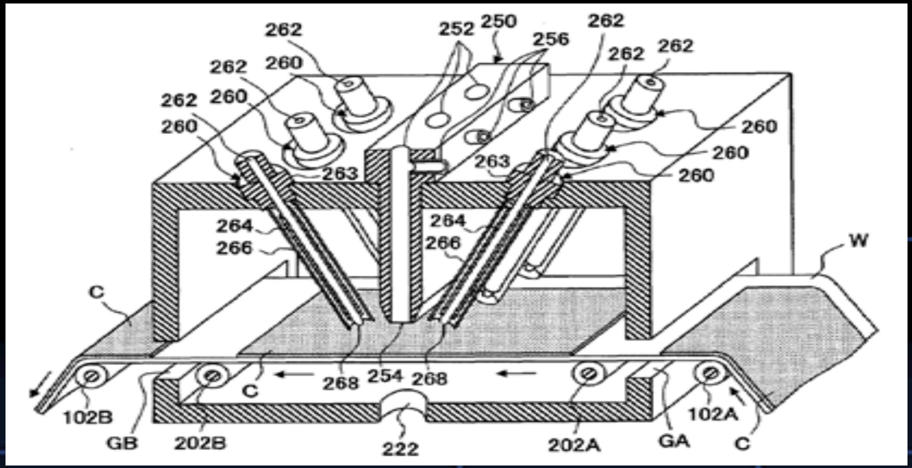


Image 6: Tokyo Electron Limited's Patented coating machine

Constraints

- The budget given by General Capacitors is $2,000
- The lithium powder is to cover the total surface area of the flat battery's anode
  - The anode dimensions will vary from 5-12 cm (width) and 5-25 cm (length)
- Lithium coat must have a uniform layer of 150μm with 20% fluctuation in thickness
- One coating process under 10 minutes
- Working with the lithium powder must be done in a dry environment
  - AME dry room is 0.5% humidity

Current Design

Process / Component Breakdown

- Process is divided into 3 major parts
  - Powder dispersion
  - Powder coating
  - Powder pressing

- To understand each process will going into a detailed step by step procedure along with component breakdowns

Current Design

- Updated version of prototype

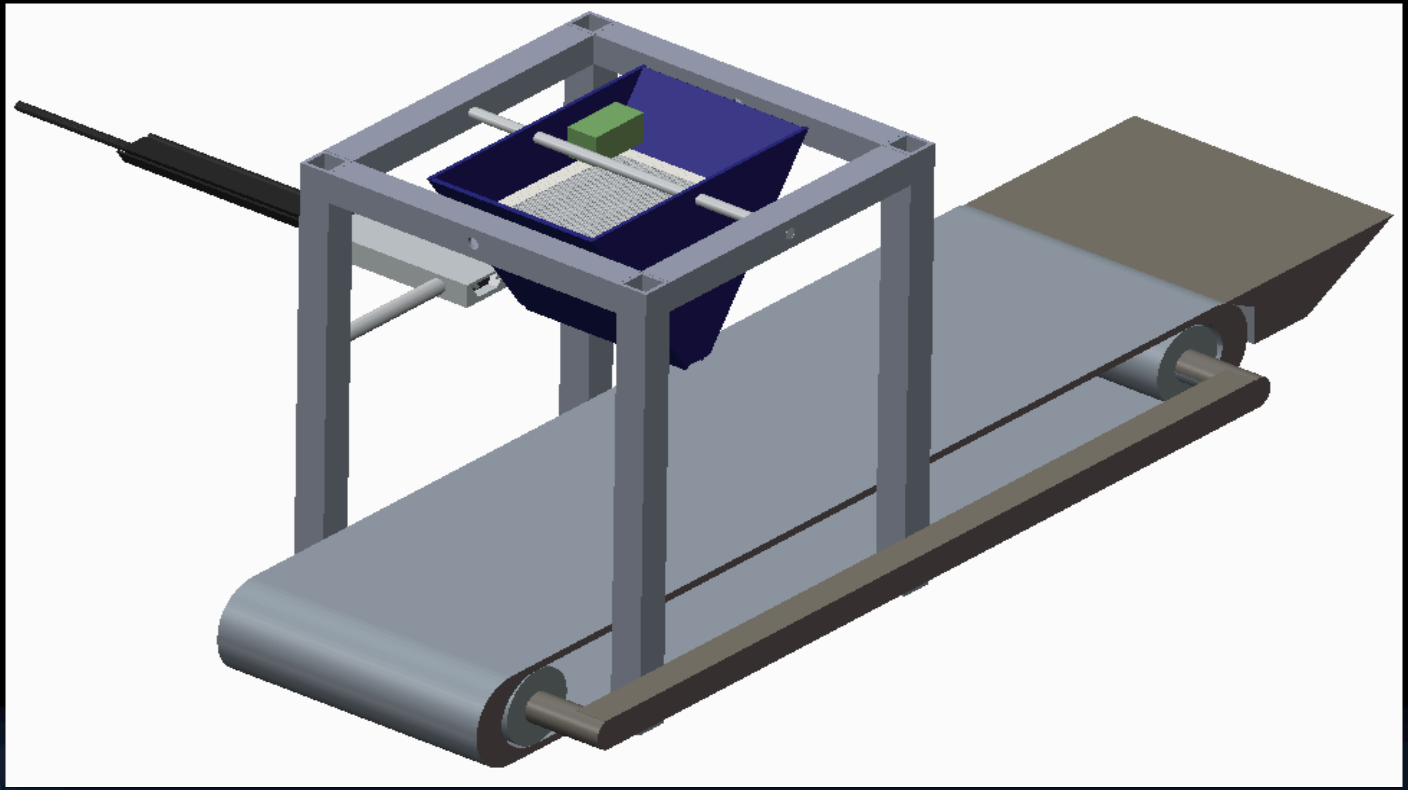


Image 7: Completed CAD Drawing of Prototype machine which includes all changes that occurred due to construction issues that arise.

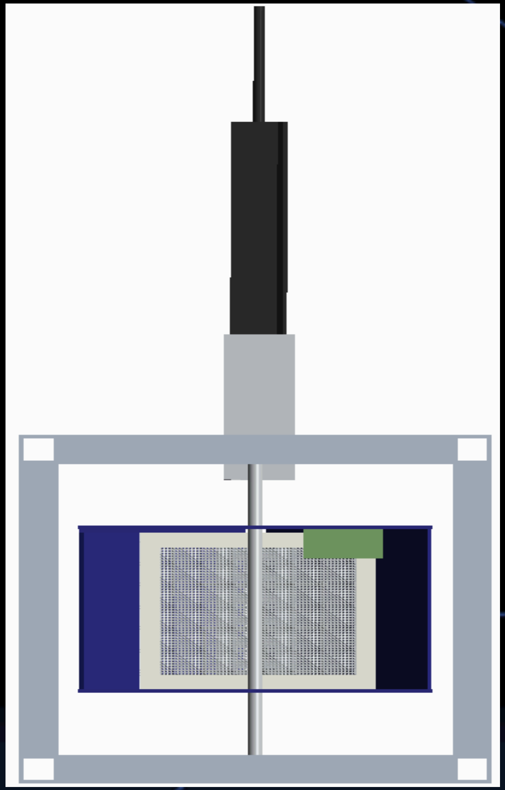
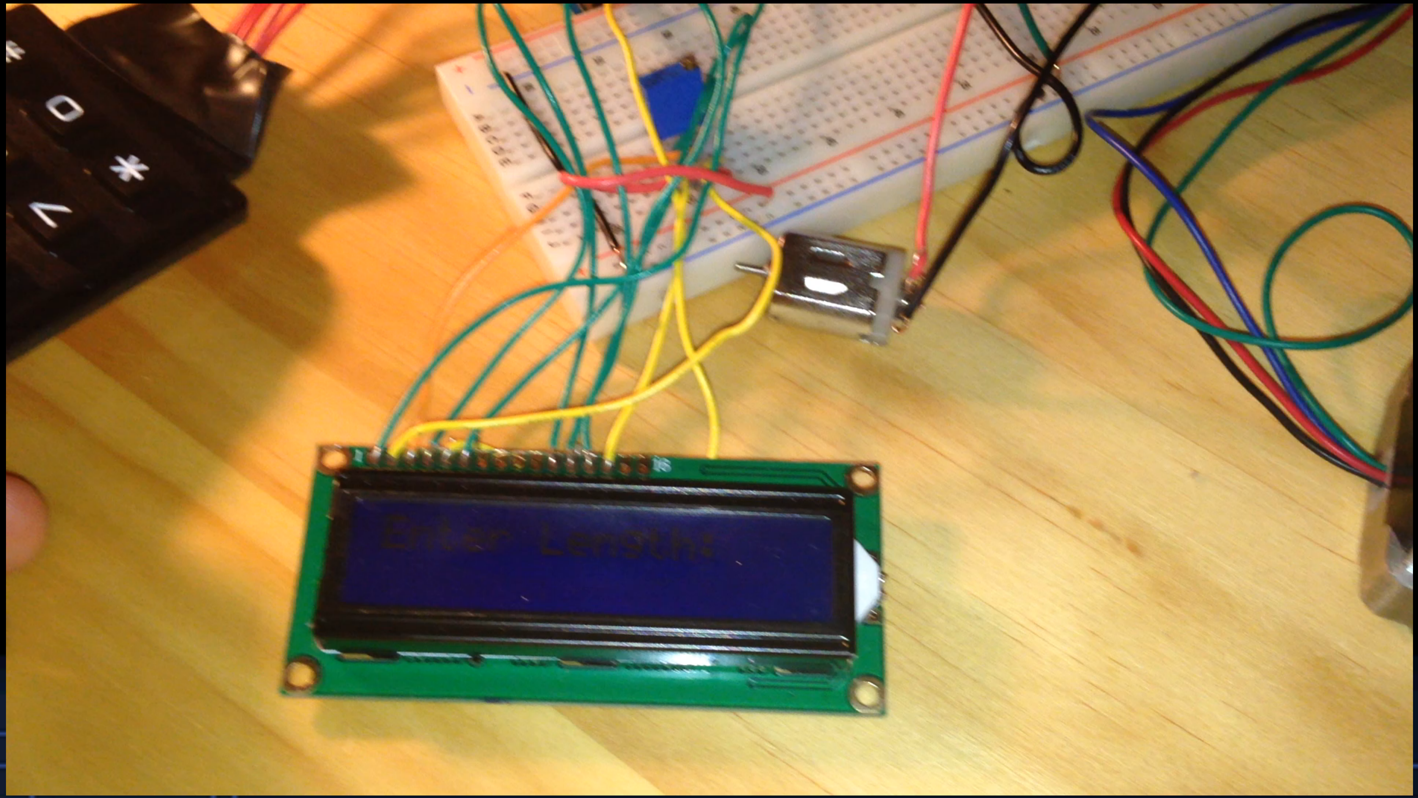


Image 8: Top View of updated prototype.

Current Design

- To begin the coating process, the user will first be prompted to use the keypad and LCD display to communicate with the microcontroller.



- 16X2 character LCD used to communicate with the user
- 3X4 numeric keypad is used for the user to enter coating length

Table 1: Commands available for key pad.

Key Pressed	Result
*	Re-enter Length
#	Select Length
Value < 5 or > 25	Invalid Length: Re-enter Length
Value > 5 and < 25	Begin Coating Process

Current Design

Process / Component Breakdown

Microprocessor

- MCU - Arduino Mega 2560 R3 Microcontroller
  - This MCU will be the “brains” of the operation by:
    - Controlling the various motors
    - Powering on and off components
    - Controlling LCD
    - Retrieving feedback from Keypad
  - Technical Specifications
    - Input Voltage: 7-12V
    - Digital I/O Pins: 54
    - PWM Digital I/O Pins: 15
    - Flash Memory: 256 Kb
    - Clock Speed: 16 MHz
  - Powered by 12 VDC power supply with 2.1mm connector

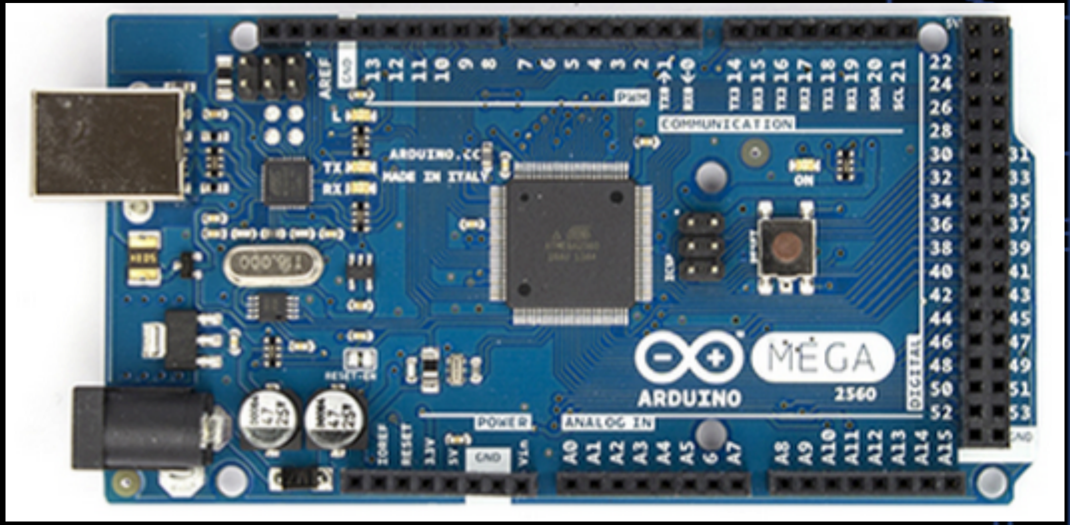


Image 9 : Arduino Mega 2560 R3

John Magner

Current Design

Process / Component Breakdown

Power Supply

- 120 VAC to 12V/ 5A power supply (60W)
- Output connects to a 2.1 mm DC plug
  - Split into (2) 2.1 mm DC plugs
    - One powering Arduino
    - One powering motors

Table 2 : Tabulated Power Consumption stating nominal voltage, average current, average power and total power

Components	Nominal Voltage (V)	Average Current	Average Power (W)	Total Power (W)
Arduino Mega	12 V	50 mA	0.6	0.6
Stepper Motor	12 V	350 mA	4.2	4.2
Vibration Actuators	12 V	100 mA	1.2	2.4
Character Display	5 V	15 mA	0.075	0.075
Keypad	2 V	10 mA	0.02	0.02
			Total Power =	7.295 W

Image 10: Photo of the 60 W Power Supply that will be used.

Image 11 : 2-Way 2.1mm DC Barrel Jack Splitter.

Current Design

Process / Component Breakdown

- Once all settings have been inputted, the user will lift the plexiglass enclosure and begin to pour SLMP into the funnel opening.
- 3 different meshes will be distributed along the length of the funnel and by use of 2 DC vibration motors, the meshes will be oscillated to facilitate flow rate and to produce a uniform particle distribution

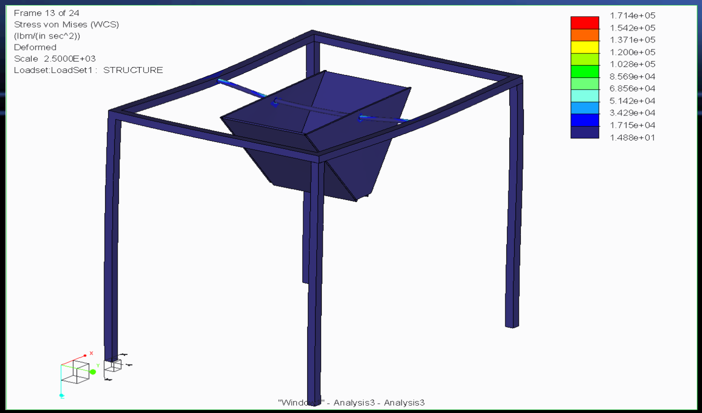


Image 12: Larger image showing how the structure would react with 2500 psi onto it .

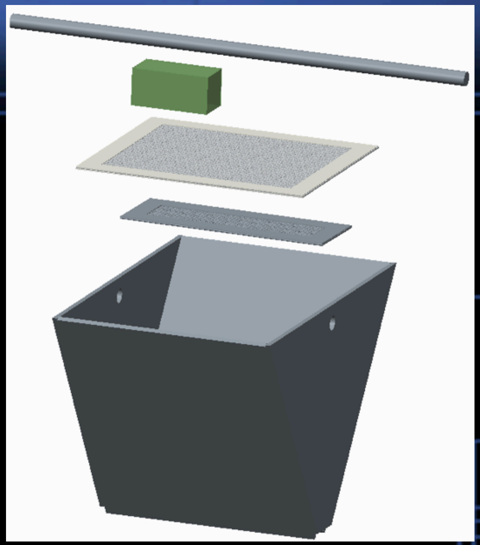


Image 14: Exploded CAD drawing of the funnel with the meshes and Actuators.

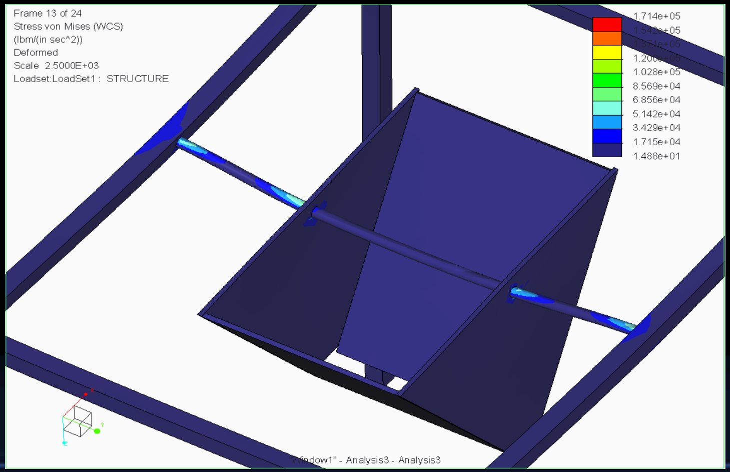


Image 13 : FEM Analysis of forces acting on structure. Showing the Stress in the rod holding the funnel

Image 15 : Photo of the wire cloth mesh that will be utilized.

Current Design

Process / Component Breakdown

Actuators

- When the dispersion process begins actuators will be turned on to vibrate the meshes and allow for the SLMP to flow.
- There will be (3) actuators powered by the 12 VDC power supply used on separate meshes vibrating at different amplitude and frequencies.
- The Actuators will be controlled by the microprocessor and a BJT.
    - The 12V power supply is connected to the collector
    - The Arduino pin is connected to the base
    - The actuator is connected to the emitter
- A diode is also placed in parallel to the actuator for protection from back-currents.

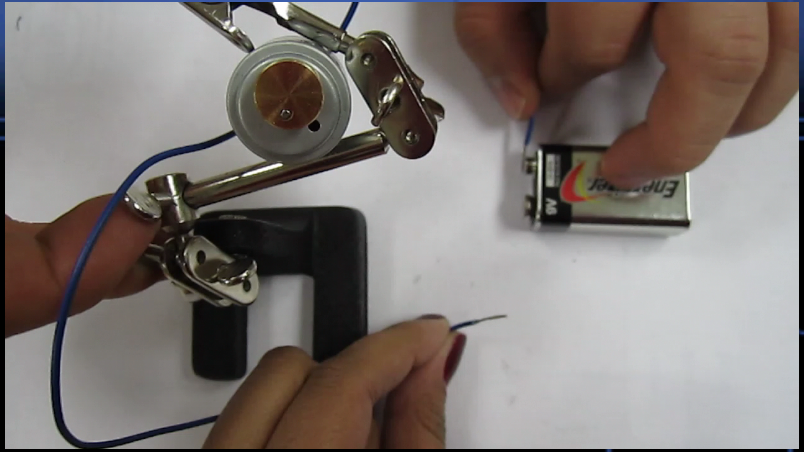


Image 16 : DC vibration motor of 4,500 rpm.

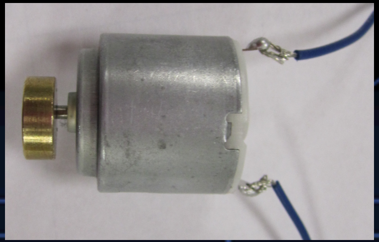


Image 17 : DC vibration motor of 7,100 rpm.

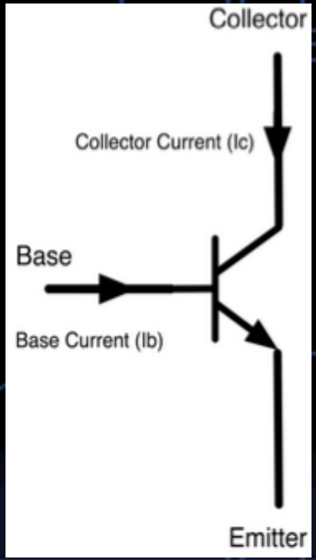


Image18 : NPN BJT

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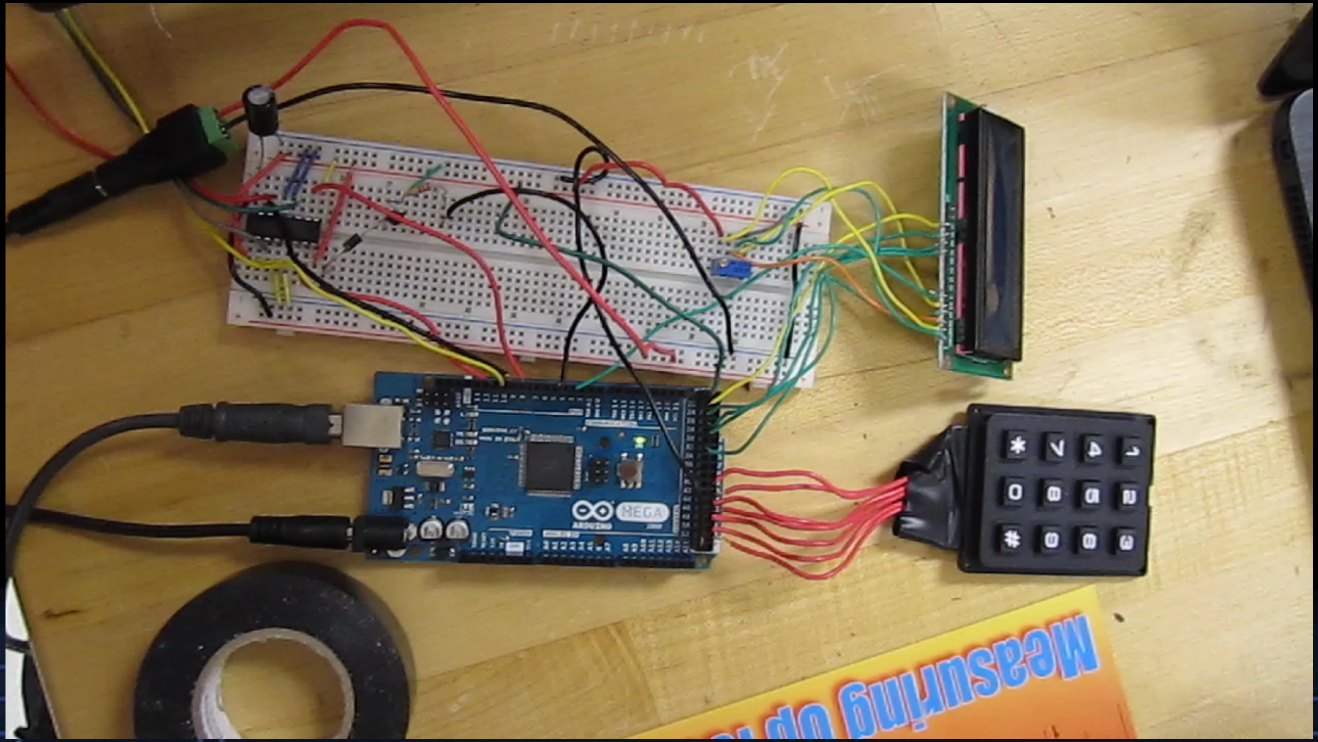
Current Design

Process / Component Breakdown

- Directly beneath the outlet of the funnel, an anode on a conveyor belt will be waiting to be coated.



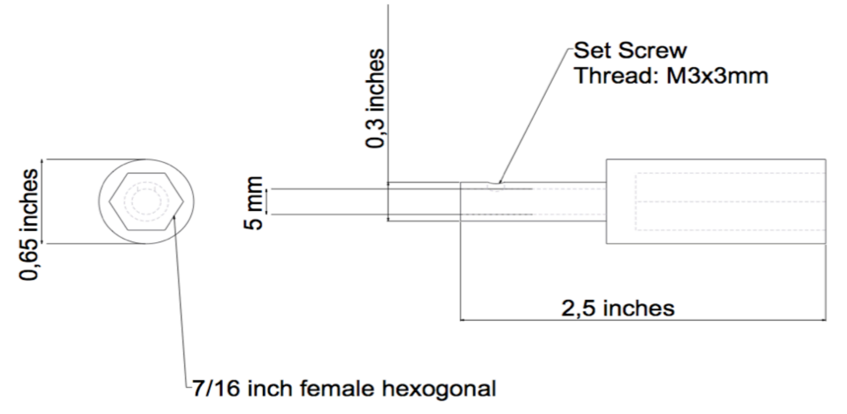
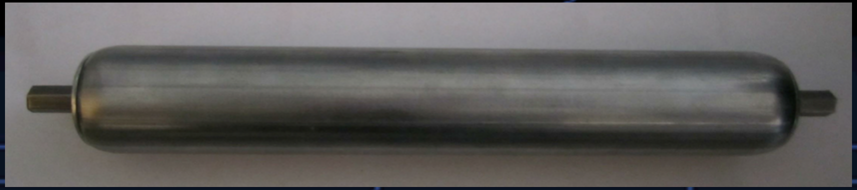


Image 19: CAD Drawing of hexagonal adaptor, not to scale. (above)
Image 20 : Photo of the conveyor roller being utilized. (below)



Vannesa Palomo
SLMP Coating Machine

Current Design

Process / Component Breakdown

Conveyor Motor

- A 12V stepper motor will be used to drive and control the conveyor belt.
  - A set number of steps will bring anode from start position to funnel and from funnel to end.
  - While the anode is under the funnel the conveyor belt will go back and forward 5 times each at the distance specified by the user.
- The amount of steps for a given distance can be calculated by comparing the steps to circumference
- The circumference of the rollers are 15.16 cm and the motor has 200 steps per rotation.
  - Circumference = pi*d
  - Revolutions = Circumference * Length
  - Steps = Revolutions * 200
- An H-bridge is used to give the stepper motor bi-directional capabilities.

Table 3: Length to step Conversions

Length (cm)	Revolutions	Steps
< 5	0	Re-enter
5	0.33	66
6	0.40	79
7	0.46	92
8	0.53	106
9	0.59	119
10	0.66	132
11	0.73	145
12	0.79	158
13	0.86	171
14	0.92	185
15	0.99	198
16	1.06	211
17	1.12	224
18	1.19	237
19	1.25	251
20	1.32	264
21	1.39	277
22	1.45	290
23	1.52	303
24	1.58	317
25	1.65	330
> 25	0	Re-enter

Progress To Date

- Frame and Funnel Construction Complete
- Conveyor Belt Complications resolved
  - Hexagonal drive shaft
  - adaptor created for stepper motor and roller connection
  - slip of belt on rollers
- Testing with appropriate actuators commenced
  - Brushless Oscillators Replaced
    - Now using DC motor with offset weights
- Stepper Motor programming is complete
  - will be able to rotate the conveyor belt for anode coating.
- Keypad and LCD programming is complete
  - LCD will communicate messages to user
  - Keypad will accept user inputs

Challenges / Lessons Learned

- Conveyor Belt Issues
  - Had to come up a contingency plan to convert one of them into a driver rollers
- Connection of Stepper Motor to Hexagonal Drive
  - Creating a 3D printed adaptor
- Rolling press is no longer functional
  - will be using a flat press
- Original Actuators did not produce sufficient vibration.
  - Changed type of actuator
- Construction timeline has been delayed due to shipment delays
  - Team must meet more consistently to account for approach deadline

Future Plans

- Installations
  - Conveyor belt and Frame Connections
  - Meshes within the Metal funnel
  - Plexiglass enclosure
  - Construction of 3D parts
  - Testing with Actuators
    - inside funnel
    - outside of funnel
- Begin testing with completed mechanism
- Begin testing in Dry Room

Budget

- Currently we have used $1249.35 of our $2000 budget.

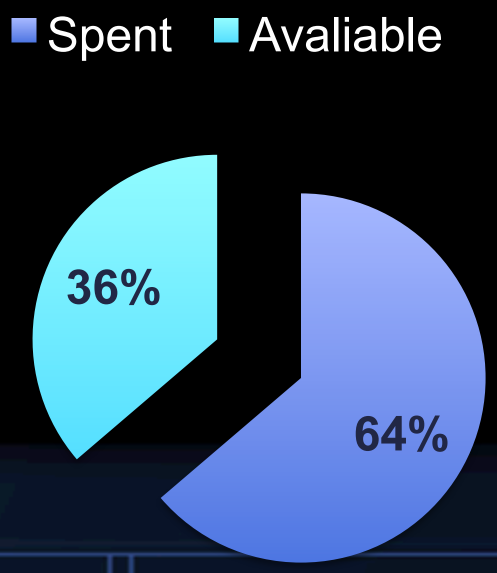


Table 4 : Tabulation of all material spent as of current progress.

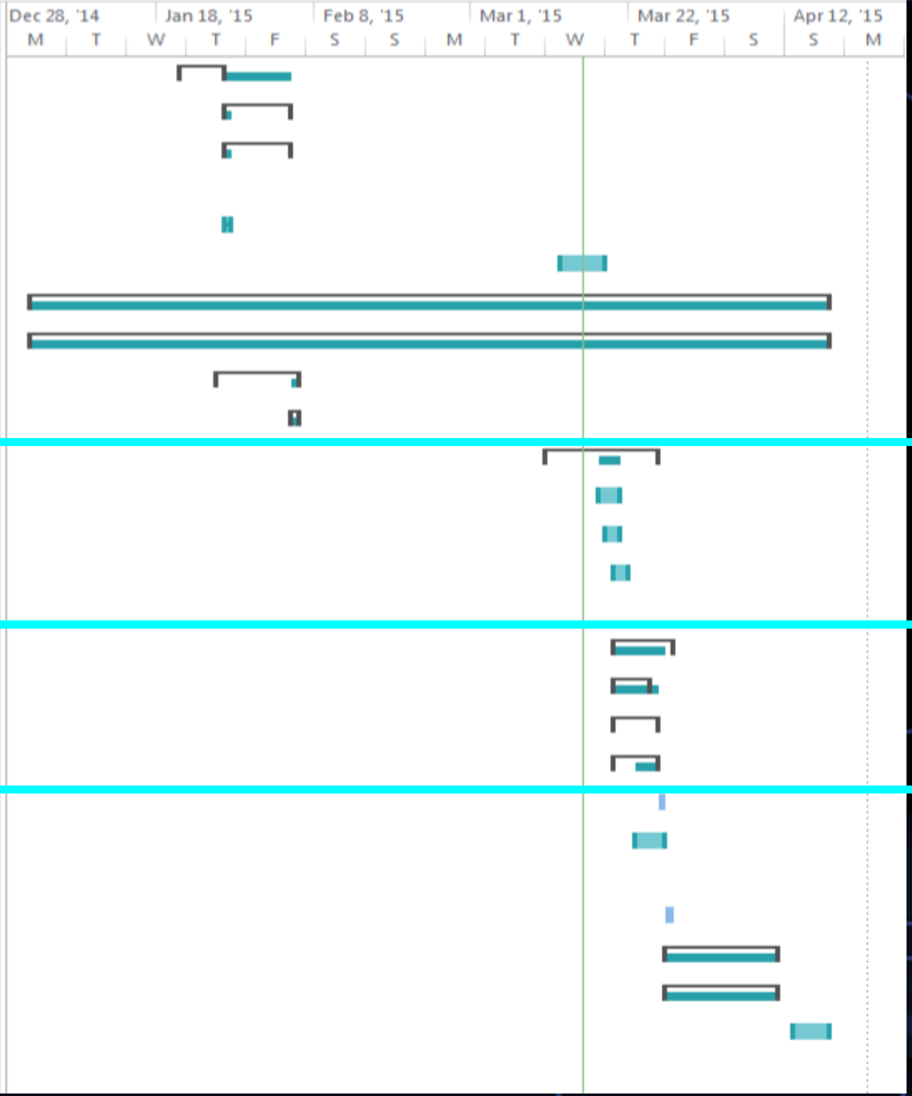
Component	Distributor/Source of Part	Total Price
Meshes	Grainger Industrial Supply	$ 65.38
Frame & Funnel	Metal Fabrications and Sales of Tallahassee	$ 527.62
Rollers	Grainger Industrial Supply	$ 48.60
Conveyor Belt	Grainger Industrial Supply	$ 52.00
Actuators	Precision Microdrives	$ 63.75
Plexigalss	Amazon	$ 7.99
Microprocessor	Arduino	$ 44.99
Stepper Motor	Adafruit	$ 14.00
DC Motor	Phigidt	$ 43.50
LCD character display	Sparkfun	$ 4.99
Keypad	Sparkfun	$ 8.99
On/Off switch	Sparkfun	$ 1.99
Power Supply	Adafruit	$ 24.95
Hinges	Home Depot	$ 3.39
Motor Shield	Amazon	$ 34.95
Corner Bracers for Convyor Belt	Home Depot	$ 5.94
Clamps	Home Depot	$ 4.99
Acrylic Mirror	Home Depot	$ 55.99
Misc. Electrical Components	Adafruit/ Radioshack	$ 35.00
Misc. Hardware	Home Depot	$ 200.34
	Total	1249.35

John Magner

Updated Schedule

Table 5: Updated Gantt Chart of current schedule

Task Name	Duration	Start	Finish
Construction of wooden frame	4 days	Wed 1/21/15	Mon 1/26/15
Testing of Meshes using Wooden frame	7 days	Tue 1/27/15	Wed 2/4/15
Testing of Meshes with Brushless actuators	7 days	Tue 1/27/15	Wed 2/4/15
Order placement of need parts	1 day	Tue 1/27/15	Tue 1/27/15
Creation of Frame for Meshes	4 days	Fri 3/13/15	Wed 3/18/15
Programming of Arduino	77 days	Thu 1/1/15	Fri 4/17/15
testing	77 days	Thu 1/1/15	Fri 4/17/15
Pick up of Metal Frame (Funnel and Stand)	9 days	Mon 1/26/15	Thu 2/5/15
Check of frame against drawings	1 day?	Thu 2/5/15	Thu 2/5/15
Construction of Conveyor belt	11 days	Wed 3/11/15	Wed 3/25/15
Testing of conveyor belt with Program	3 days	Wed 3/18/15	Fri 3/20/15
Assembly of Conveyor belt with Frame	2 days	Thu 3/19/15	Fri 3/20/15
Test conveyor rotation for optimum powder dispersion	2 days	Fri 3/20/15	Sat 3/21/15
Installation	6 days	Fri 3/20/15	Fri 3/27/15
Meshes in the funnel	3 days	Fri 3/20/15	Tue 3/24/15
Actuators on meshes	4 days	Fri 3/20/15	Wed 3/25/15
Testing of Location Choice	4 days	Fri 3/20/15	Wed 3/25/15
Plexiglass covering	1 day	Thu 3/26/15	Thu 3/26/15
Placement of all electrical components/ Housing	4 days	Mon 3/23/15	Thu 3/26/15
Final Check of Mechanism	1 day	Fri 3/27/15	Fri 3/27/15
Final Round of Testing Initiated	11 days	Fri 3/27/15	Fri 4/10/15
Dry Testing	11 days	Fri 3/27/15	Fri 4/10/15
Presentation of Completed Prototype to Sponsor	5 days	Mon 4/13/15	Fri 4/17/15



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References

- FMC Corporation, O. "Introducing Stabilized Lithium Metal Powder." *SLMP — More Energy, More Stability, More Value. Only from FMC Lithium.* (n.d.): n. pag. *Introducing Stabilized Lithium Metal Powder*. FMC Lithium, 2010. Web. 2014.

- Groover, M. (2010). CH 16 Powder Metallurgy. In Fundamentals of modern manufacturing: Materials, processes, and systems (5th ed., p. 1024). Upper Saddle River, N.J.: Prentice Hall.

- Zheng, J.P. "Nano-structured Materials for Energy Storage and Conversion." *Anode Electrode*. N.p., n.d. Web. 2014.

Questions/Comments

- We would like to open the floor to any questions or comments.