Prototype Machine for Coating Stabilized Lithium Metal Powder

Team #16 ME/ #18 ECE

Sponsor: General Capacitors LLC (Harry Chen)

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

Instructor: Dr.Gupta & Dr. Helzer

Team Members:

Marcos Leon
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Maria Sanchez
John Magner
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Benjamin Tinsley

Overview of Project

- Goal and Motivation
- Background
- Final Design Chosen
- Breakdown of Components
- Procurement
- Testing to Date
- Future Work
- Budget
- Schedule
- Initial Testing

Goal and Motivation

- Sponsor - **General Capacitor**
- Experimental material - Stabilized Lithium Metal Powder (SLMP)
- Motivation to use SLMP - Increased capacity and energy density of batteries as well as supercapacitors
- Current methods of application are complex and expensive

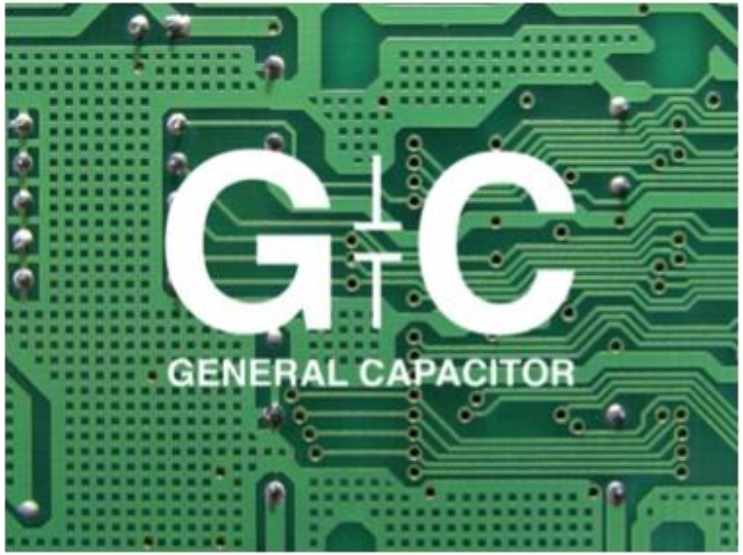

Image 1: General Capacitor Logo

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Background

- Stabilized Lithium Metal Powder or (SLMP)
  - Particle size: 30-60 Microns
- We expect our machine to coat a battery electrode with a uniform layer of SLMP increasing the batteries capacity by 5 to 15%

Image 2: Completed SLMP coated battery.

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SLMP Benefits

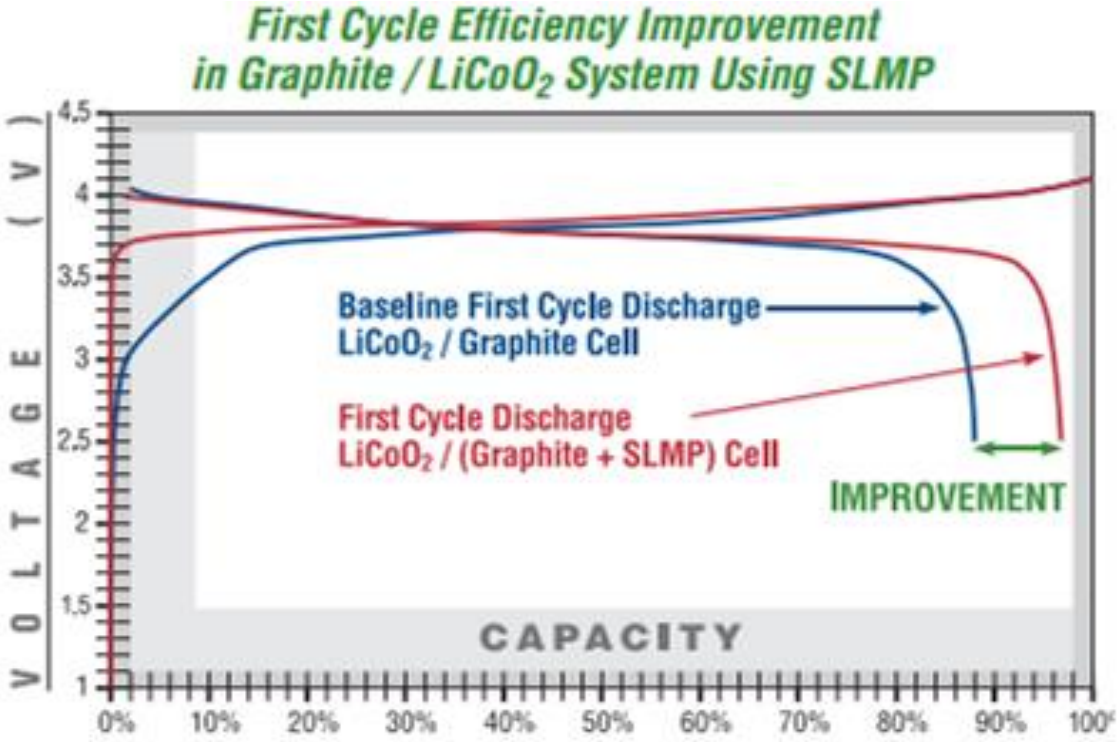

Image 3: Voltage vs Capacity graphic. Provided by FMC Lithium Corp.

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SLMP Benefits

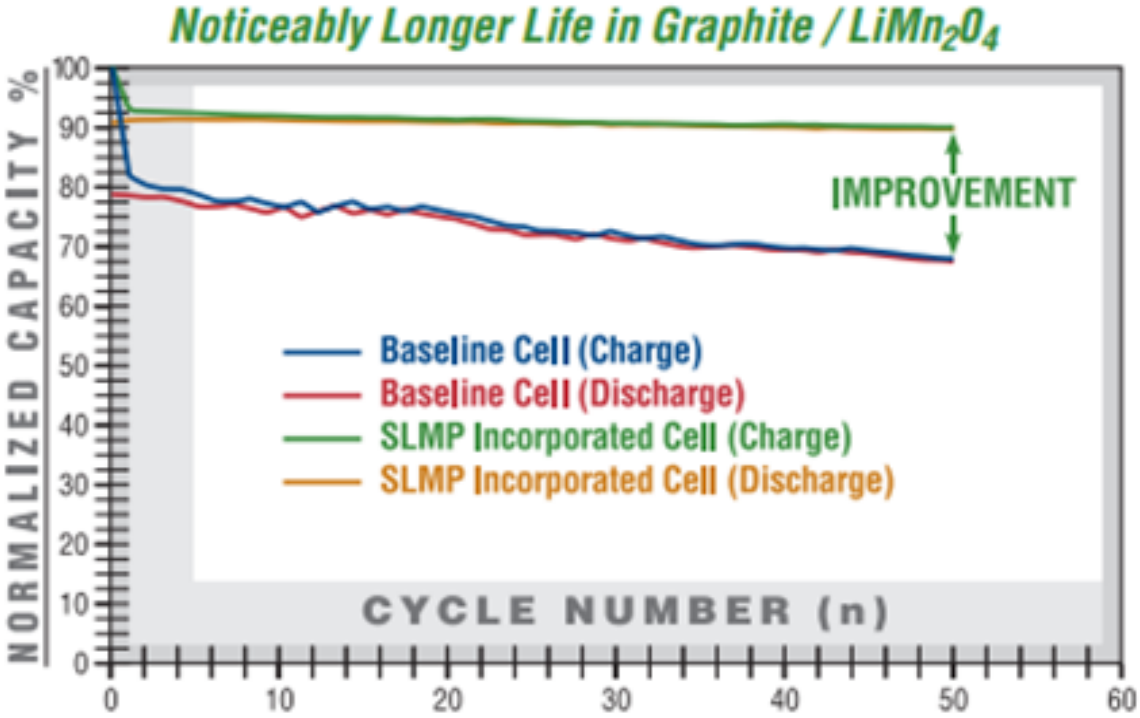

Image 4: Normalized Capacity % vs Cycle Number of standard cells and SLMP incorporated cells. Provided by FMC Lithium Corp.

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Mechanical Components

Final Design

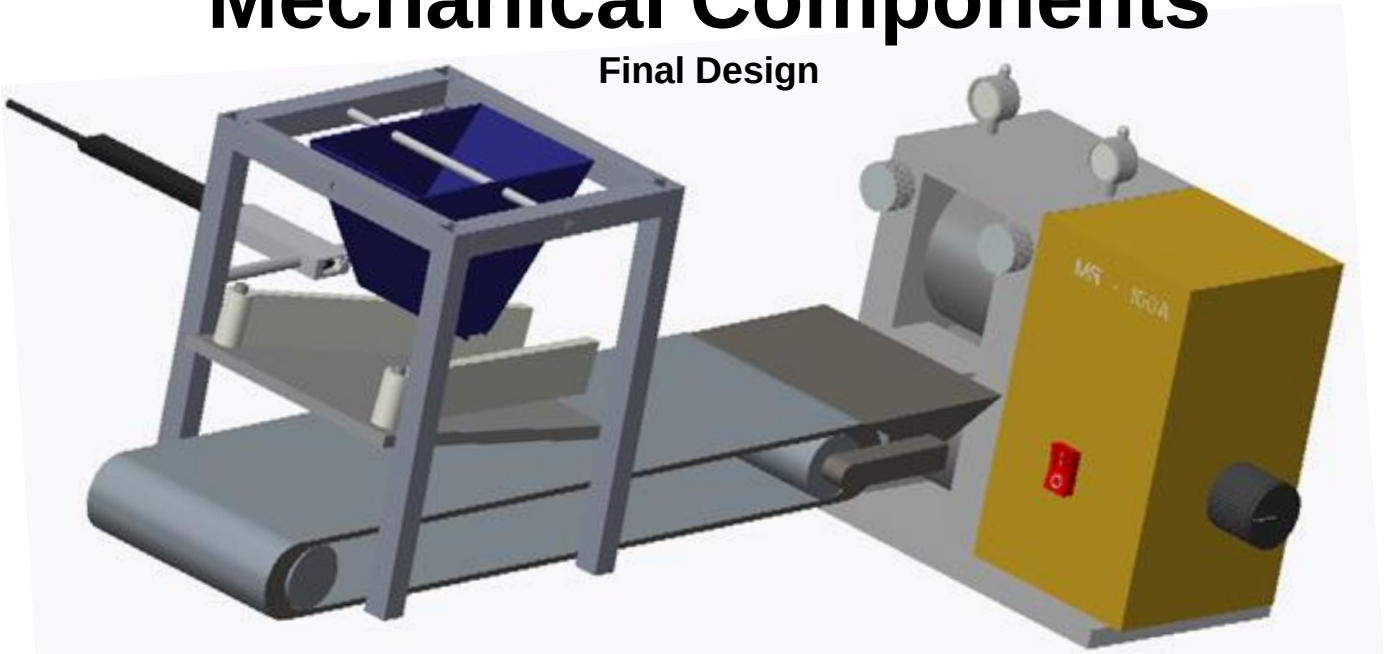

Image 5: CAD of final design.

- Dry method design
- Semi-automatic operation
- Adjustable powder flow
- Satisfies safety requirements

Mechanical Components

- Conveyor Belt
  - Function: To move anode through coating position into Rolling press
  - Procurement: In- house Construction
    - Rollers, belts, motors
- Electric Precision 4” width Rolling Press with Dual Micrometer
  - Function: To break and activate the carbonlithate coating on the SLMP coat
  - This rolling press will provide a minimum of 22.24 MPa of pressure
  - Supplied by our sponsor and liaison, Dr.Zheng
  - Manufactured by MTI Corporation

Image 6: The rolling press. Image take from MTI Corporation.

Mechanical Components Continued

Funnel Closing Mechanism

- Closes funnel output
  - Manual operation

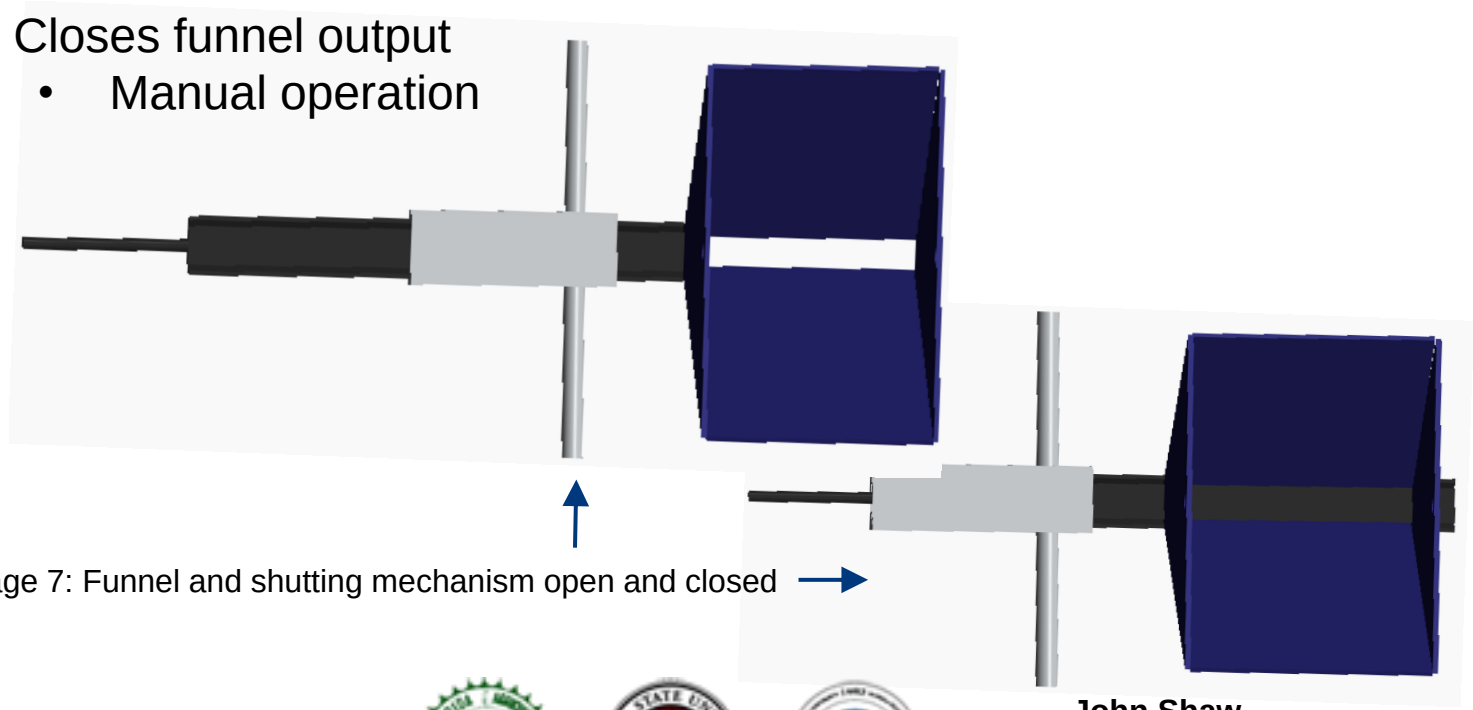

Image 7: Funnel and shutting mechanism open and closed

Mechanical Components Continued

Adjustable Ramp

- Satisfies the minimum and maximum width of the anode
  - Uses tightening screws to allow movement

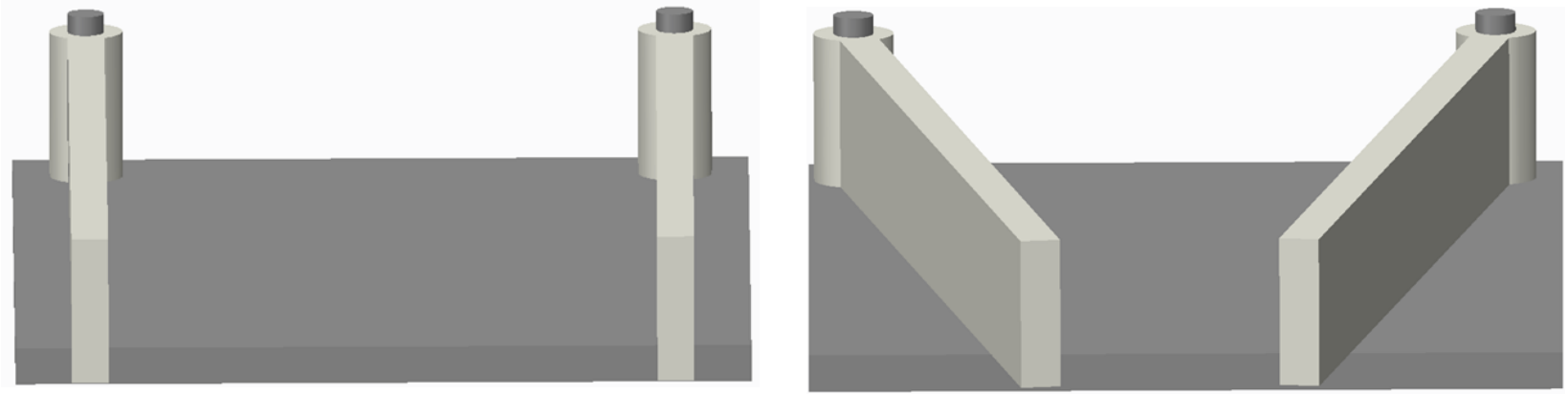

Image 8: New ramp and width adjustment flaps

Mechanical Components

Meshes

- Function: Will be used to sieve through SLMP to avoid particle agglomeration and to ensure a constant flow rate of SLMP being dropped onto anode
  - Supplier - Grainger Industrial Supply

Wire mesh	Wire Diameter	Width Opening	% Open Area	Material
150 X 150	0.06604 mm	0.10414 mm	37.90%	304 Stainless Steel
200 X 200	0.05334 mm	0.07366 mm	33.60%	304 Stainless Steel
250 X 250	0.04064 mm	0.06096 mm	36.00%	304 Stainless Steel

Table 1: Meshes

Mechanical Components

- Vibrating Actuators
  - Function: to induce mesh vibrations, promoting consistent flows
  - Supplier: Precision Microdrives

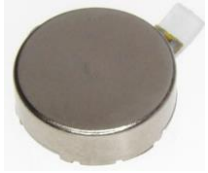

Image 9.Vibration actuator
Product number: 310-117

Product Number	Product Name	Quantity	Voltage	Amplitude
310-004	Pico Vibe 10mm vibration motor	1	1.5 V	0.5 G
310-117	Pico Vibe 10mm vibration motor	2	3 V	1.9 G
310-118	Pico Vibe 10mm vibration motor	1	3 V	1.1 G

Table 2: Actuators

Electrical Components

- MCU - Arduino Uno R3 Microcontroller
  - This MCU will be the “brains” of the operation by:
    - Controlling the various motors
    - Allows for a on/off switch control the machine
  - Technical Specifications
    - Input Voltage: 7-12V
    - Digital I/O Pins:14
    - PWM Digital I/O Pins: 6
    - Flash Memory: 32 Kb
    - Clock Speed: 16 MHz
    - Capable of being powered by a USB connection from an AC to 12V DC converter.
- Adafruit Motor Shield
  - stackable allowing for 2 additional stepper motors to be controlled
    - 3A peak current capacity

Image 10: Arduino Uno R3 Front View

Electrical Components

- (1) 12V Stepper motor with Encoder for conveyor belt.
- 16X2 Character Display to communicate with user
- On/Off Switch
- 12 key – Keypad
- A 350W (Corsair RM350) power supply will be needed to supply power.

Image 11: 16X2 Character Display

Components	Nominal Voltage (V)	Average Current	Average Power (W)	Total Power (W)
Arduino Uno R3 - MCU	12 V	50 (mA)	0.6	**0.6**
Conveyor DC Motor	12 V	1.1 (A)	13.2	**13.2**
Vibration Actuators (4)	2 V	69 (mA)	0.138	**0.552**
Character Display	5 V	15 (mA)	0.075	**0.075**
Keypad	2 V	10 (mA)	0.02	**0.02**
Encoder	5.5 V	27 (mA)	0.149	**0.149**
			Total Power	**14.596 (W)**

Table 3: Power Consumption

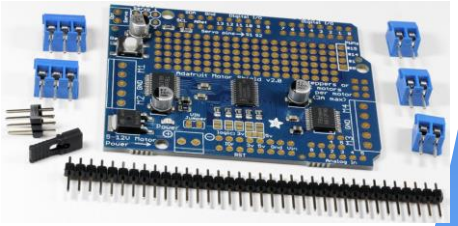

Image 12: Arduino Motor Shield

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Programming Flow Chart

- Programming Language:
  - Arduino coding
- Estimated Time for completion of Program
  - Goal : Late-February
- Additional Debugging and modifications that may arise to be completed beginning of March

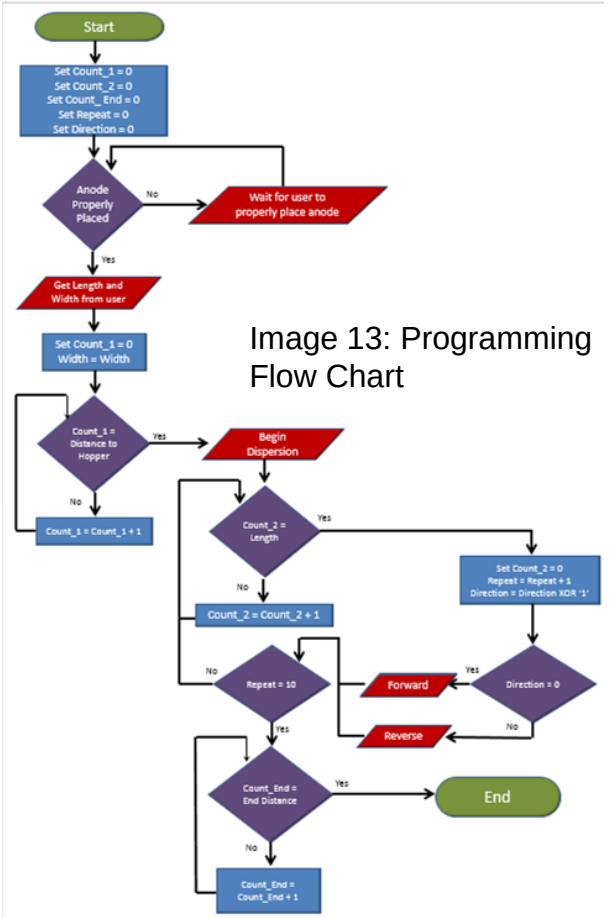

Image 13: Programming Flow Chart

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Block Diagram

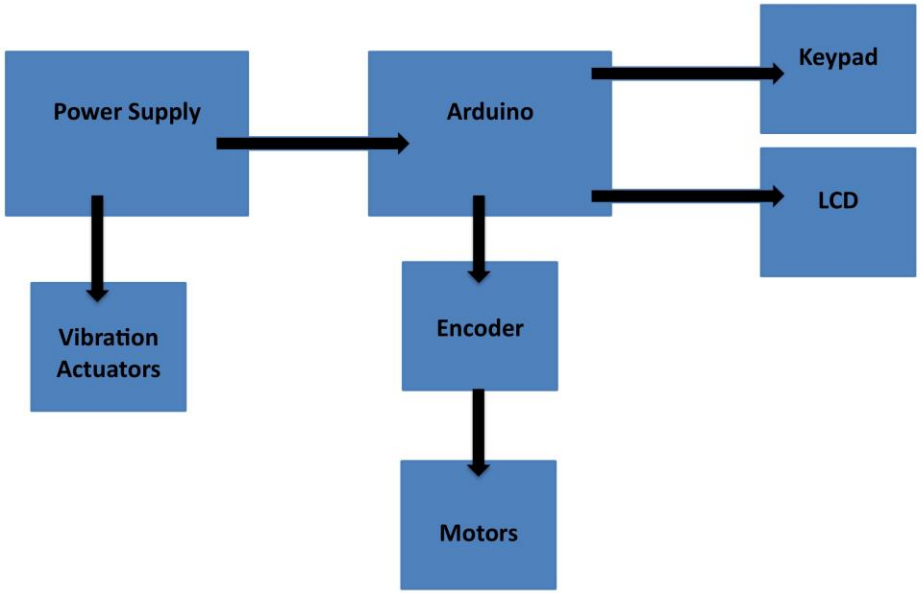

Image 14: Block diagram of Electrical Components

Circuit Diagram

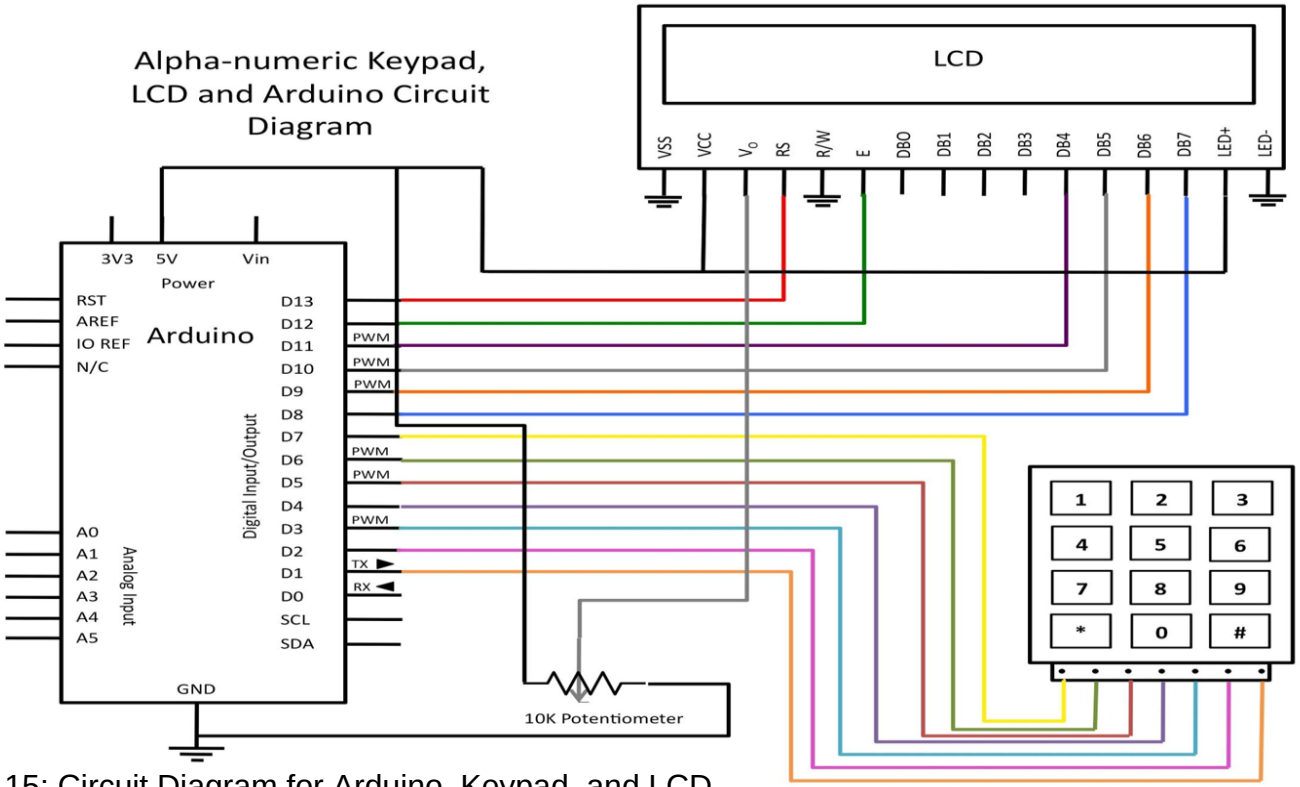

Image 15: Circuit Diagram for Arduino, Keypad, and LCD

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Testing - to date

- Conduct experiments with different mediums:
  - Sugar
  - Flour
  - Carbon Black Microparticles
- Completed:
  - Manual sifting of meshes with flour
    - Results: Inconclusive due to flour grain size and open diameter of mesh.
  - Actuator vibrations
    - Results: Higher voltage actuators might be needed
- Machine Testing:
  - Begin testing with actuators and funnel to determine flow rate and dispersion area

Image 16: Photo of Dr.Zheng's Lab Dry Room

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Future Work

Before Midterm Presentation 2 on 3/17/15

- The construction of prototype completed by **2/27/15**
- First testing session will be completed - beginning **2/28/15**: estimated completion **3/13/15**
  - Positioning of meshes tested (inside and outside funnel)
  - Positioning of actuators tested (on meshes vs. inside funnel)
  - Analysis of flow rates of different meshes (actual flow rates)
  - Angle of ramp tested

Budget Table

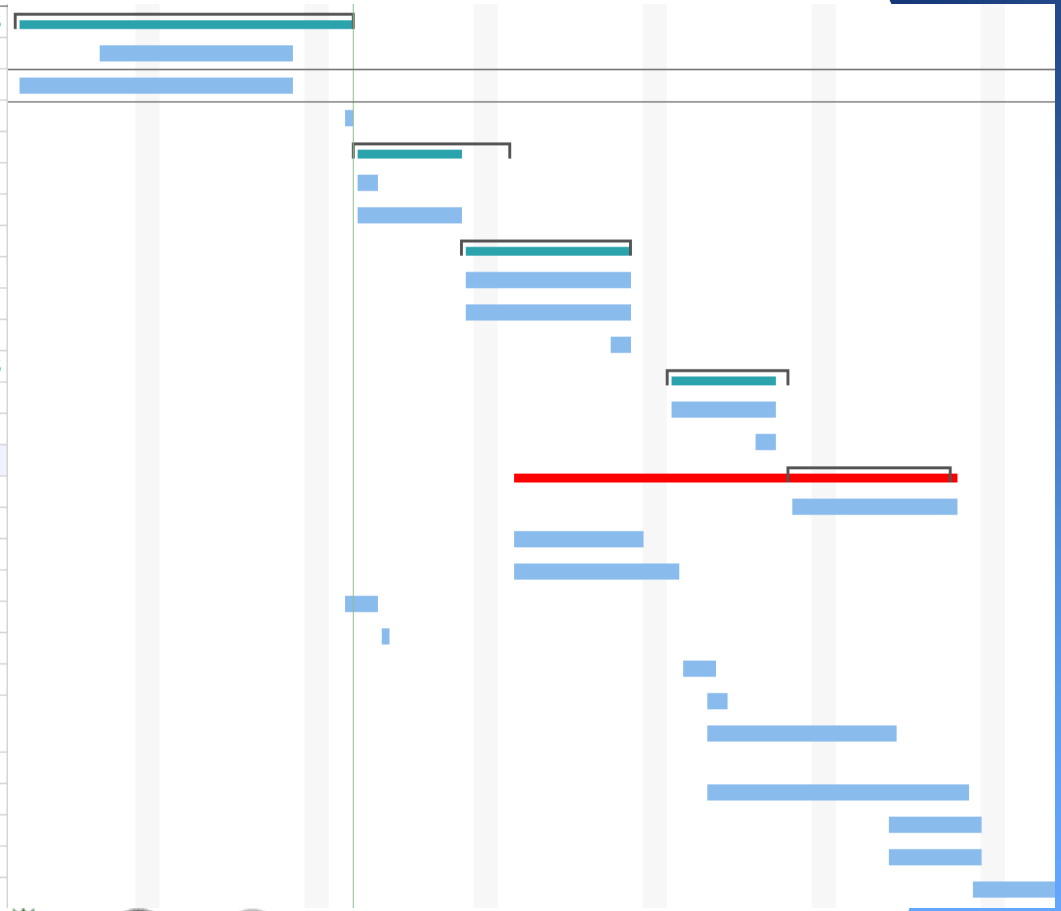
Component	Distributor/Source of Part	Quantity	Price per Unit	Total Price	Status of component
Meshes	Grainger Industrial Supply	3	$21.79	$65.38	Arrived
Frame & Funnel	Metal Fabrication and Sales of Tallahassee	1	$366.62	$366.62	Fabrication Phase
Rollers	Grainger Industrial Supply	2	$24.30	$48.60	In-Transit
Conveyor Belt Bed	Grainger Industrial Supply	8	$6.50	$52.00	In-Transit
Actuators	Precision Microdrives	4	$15.95	$63.79	Arrived
Plexiglass	Amazon	1	$7.99	$7.99	Arrived
Microprocessor	Arduino	1	$29.95	$29.95	Arrived
Stepper motor	Sparkfun	2	$32.99	$65.98	In-Transit
DC gear motor w/encoder	Phigidt	1	$43.50	$43.50	Ordered
character display	Sparkfun	1	$4.99	$4.99	Arrived
keypad	Sparkfun	1	$8.99	$8.99	Arrived
on/off switch	Sparkfun	1	$1.99	$1.99	Arrived
Power Supply	Cosair	1	$39.99	$39.99	Awaiting Shipment
Hinges	Home Depot	2	$1.70	$3.39	Arrived
Motor Shield	Amazon	1	$34.95	$34.95	In-Transit
Metal Sheet- Aluminum	Home Depot	3	$5.72	$17.16	Awaiting Shipment
Metal sheets-Plain Steel	Home Depot	1	$6.97	$6.97	Awaiting Shipment
Metal Shaft	Home Depot	1	$4.97	$4.97	Awaiting Shipment
Corner Braces for conveyor belt	Home Depot	2	$2.97	$5.94	Awaiting Shipment
Clamps	Home Depot	4	$4.97	$19.88	Awaiting Shipment
Acrylic Mirror	Home Depot	1	$55.99	$55.99	Awaiting Shipment
			Total	$949.02	

Budget

- Total Budget
  - $2,000 USD
- Current Funds Spent on Procurement:
  - $ 949.02 USD
- 47.45% of budget has been used

Schedule

Procurement	**20.63 days**	**Wed 1/21/15**	**Wed 2/18/15**
Place orders on all parts	12.5 days?	Tue 1/27/15	Fri 2/13/15
Purchase of all standard parts	17 days?	Wed 1/21/15	Fri 2/13/15
Submit paperwork for reimbursement	1 day?	Tue 2/17/15	Wed 2/18/15
Construction	**9.63 days**	**Wed 2/18/15**	**Tue 3/3/15**
Initiation of Construction	2 days?	Wed 2/18/15	Fri 2/20/15
Completion of Mechanism	7 days?	Wed 2/18/15	Fri 2/27/15
Initiate Testing	**10.63 days**	**Fri 2/27/15**	**Fri 3/13/15**
Using Alternative mediums	10 days?	Fri 2/27/15	Fri 3/13/15
Analysis of round 1 of testing	10 days?	Fri 2/27/15	Fri 3/13/15
Revision mechanism	2 days?	Wed 3/11/15	Fri 3/13/15
Testing Round 2	**8.63 days**	**Mon 3/16/15**	**Wed 3/25/15**
Analysis of round 2	7 days?	Mon 3/16/15	Wed 3/25/15
Revisions based on round 2 of testing	2 days?	Mon 3/23/15	Wed 3/25/15
Final Stage of testing	**10.63 days**	**Thu 3/26/15**	**Thu 4/9/15**
Final check of system	10 days	Thu 3/26/15	Wed 4/8/15
Test Using SLMP	8.5 days?	Tue 3/3/15	Fri 3/13/15
Complete any revisions required	10 days	Tue 3/3/15	Mon 3/16/15
Midterm Presentation 1	2.5 days?	Tue 2/17/15	Thu 2/19/15
Team Evaluation 2	1 day?	Fri 2/20/15	Fri 2/20/15
Midterm Presentation 2	2.5 days?	Tue 3/17/15	Thu 3/19/15
Team evalution 3	1.5 days?	Thu 3/19/15	Fri 3/20/15
Operational Manual, Design Report for Manufacturing/ Relability and Economics	11.5 days?	Thu 3/19/15	Fri 4/3/15
Walk through Presentation	15.5 days?	Thu 3/19/15	Thu 4/9/15
Final Report	5.5 days?	Fri 4/3/15	Fri 4/10/15
Final Webpage	5.5 days?	Fri 4/3/15	Fri 4/10/15
Final Presentation	5.5 days?	Fri 4/10/15	Fri 4/17/15
Team Evaluations 4	1 day?	Thu 1/1/15	Thu 1/1/15



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Challenges Faced/Lessons Learned

- Flowing communication between sponsor and team
  - due to design changes suggested by sponsor
    - leading to further delays in final designs completion
    - leading to a delays in manufacturing

- Due to SLMP recent development concept is original

- Ordering of materials has proven challenge
  - due to communication difficulties orders were backlogged
  - due to not following up with companies ordered had to be canceled and re-order

- Initial testing was deemed Inconclusive
  - Flour particle size much larger than opening diameter of meshes
  - Attempted to switch medium to confectioners sugar
    - Grains were able to flow through but the actuator frequency was deem too low
      - Higher Frequency Actuators ordered

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.