Team 2

Team 2

Aligning Carbon Nanotubes for Potable Water Filters

Members : Anthony Aiello, Besnik Kurti, Bryce Powell, Emma Zuniga Martin
Mentors: Fred Berry, Jim Condron, Dipak Narula, Tillmann Kubis

Customer Background

Under the Purdue Research Foundation, Purdue Innovate, and the Office of Technology Commercialization our sponsors saw the potential in using CNTs to filter water.

Problem Statement Scope of Work

- Countries are struggling to provide a sustainable amount of water for their populations.
- The end goal of this project's phase is to successfully create a usable CNT membrane filter for future potable water testing.
- Our solution is to control CNTs, by dispersing them and using voltage to align and capture the orientation.

Requirements

Solution Creation → Dispersion → Alignment → Capture

Project Wide

- In-depth documentation of a clear and repeatable process and procedure for CNT alignment and capture.
- Cost effective solution
- Energy efficient solution

Solution:

- Low to no opaqueness
- Curable or slowly solidifying
- Control over min and max threshold of CNT percentage by weight

Alignment

- Visible control of alignment
- Relationship between alignment speed & clumping
- Relationship between CNT concentrations and alignment
- Low viscosity medium

Capture

- Ridgid
- Fully Curable

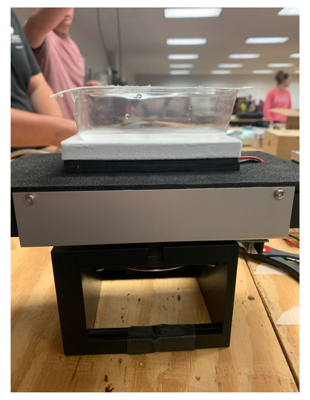
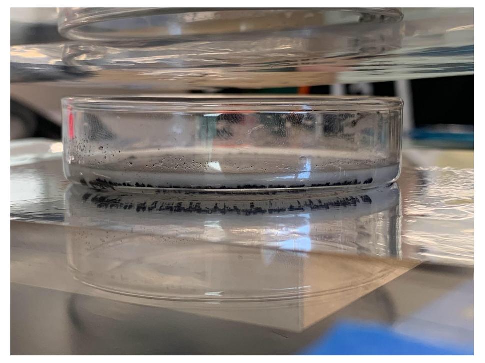
Dispersion

- Highest porosity possible
- No visible clumps

FMEA

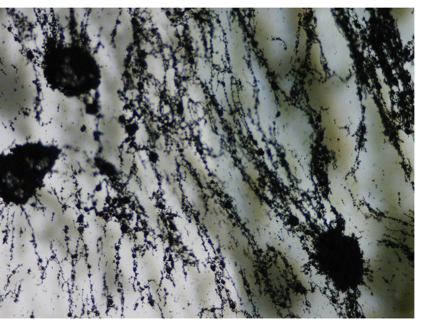
Structure Analysis	Function Analysis (Part)	Function Analysis (Function)	Failure Analysis	Risk Analysis
Power Supply	Fan	Cools power supply to prevent overheating	Sometimes is not able to cool power supply effectively	Monitor power supply, and possibly add additional fan
Capacitor	Electrodes	Aims electric field around the CNTs	Arcing can occur if they are too close together	Ensure there is an air gap of 1/2 inch or more
Glass Plate Mover Stand	Plate Holder	Holds the Glass Plate and electrode to ensure that it is high enough above the lower electrode	Holders do not hold the glass plate tightly enough	Added electrical tape to the holders for better grip
			Holders might slid down stand and drop plate	Ensure screws connecting holders to stand are tight
Peltier	Cooling Element	Cools medium to ensure uniform solidification	May not cool the medium fast enough	Ensure that the power supply is operating at optimum levels
	Peltier Holder	Holds peltier above table for better airflow of fan	Holder had slight fracture and may need to be replaced	Watch holder and move carefully to ensure no further

Experimentation and Concepts

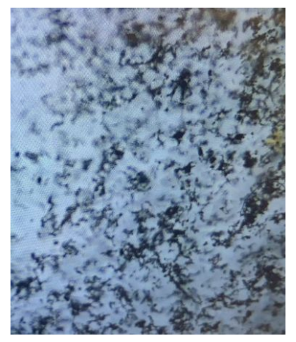
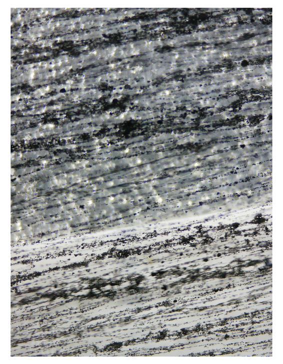
Solution Creation: Suspend CNTs within a state-changing material so that we can capture them in a rigid form

- Water
- Paraffin
- Plastics
- Gelatin
- Epoxies
- UV Resin



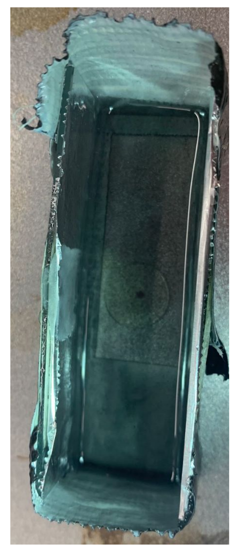

Dispersion: Different concentrations of CNTs were dispersed throughout several mediums using different methods.

- Stirring: Dispersing CNTs using a stirring stick was the simplest and most consistent method of dispersion, allowing for the greatest amount of control and observation.

Alignment: The orientation of the CNTs is crucial in allowing water to pass through our filter. Random alignment in suspension is not a possibility when making potable water.

- Vertical and Horizontal alignment
- Differing electric fields as well as air gaps



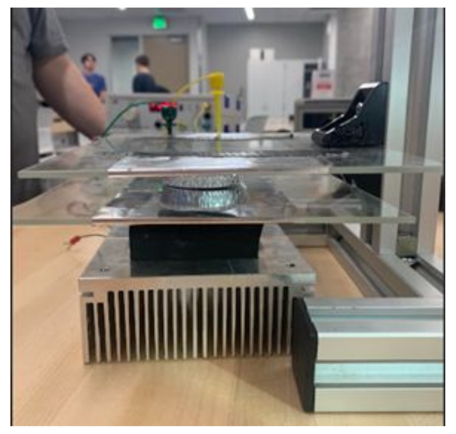
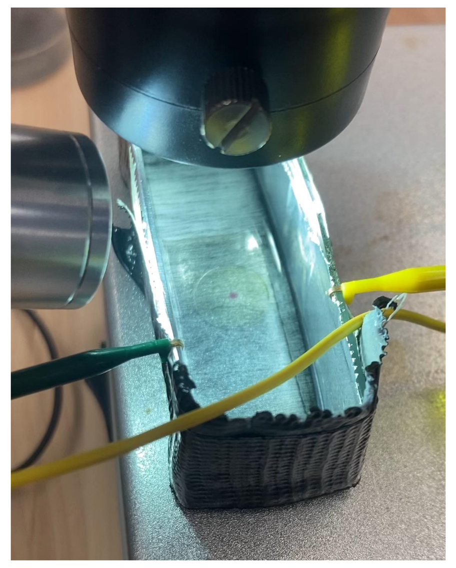
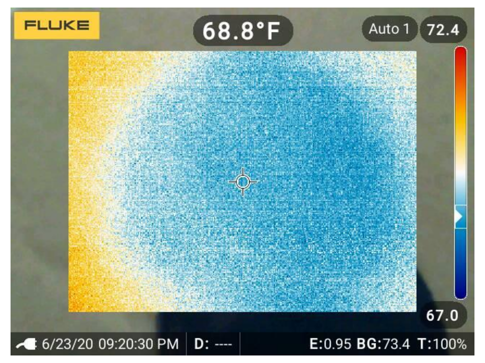

Capture: Once a solution is created, dispersed, and aligned it must then be captured within a rigid material.

- Heating/Cooling (Paraffin Wax/Gelatin/Water)
- Prolonged exposure under UV lamp (UV Resin)
- Mixing (Epoxies/Plastic)
- Air Curing

Testing

- Wax testing to find best medium for testing
- Aligning CNTs inside of paraffin wax
- Showing alignment inside of the wax
- Testing of different mediums
- Aligning CNTs inside of UV activated resin
- Testing for porosity of filter
- Increasing concentration of CNTs inside of UV resin
- Testing of CNT filter inside pressure chamber



Final Design

The final design for this project was to show that aligning CNTs is possible using an electric field. This project is not yet finished, and will be continued by another group. Lots of photos, videos, and documents will be left for them to understand our experiments and findings.

Team 20

Team 20

SMART FACTORY

INDUSTRY 4.0 STANDARD

Purdue Smart Learning Factory

Purdue Students: Austin Schneider, Brandon Thomas, Lauren Schwab, Jacob Hopkins, Nate DePugh, Jana Fusha, Datta Sheregar, Jialin Sun, Shuning Yin, & Vinnie Albanese
Purdue Mentors / Customers: Dr. Grant Richards & Dr. Ragu Athinarayanan
Purdue Professors: Dr. Fred Berry & Dr. James Condron

PURDUE POLYTECHNIC

Customer Background

Since the Purdue Polytechnic Institute was founded in 1964, the professors have dedicated their lives to help students become a driving force in a rapidly transforming digital age. Dr. Grant Richards & Dr. Ragu Athinarayanan have developed a plan to help students dive into Industry 4.0 practices while developing a SMART manufacturing process to help with future education. By providing access to industry leading software and hardware, Purdue has developed a bridge between education and implementation.

Problem Statement / Scope of Work

The School of Engineering Technology is in need of a SMART manufacturing process that engages students in the merge of Operation Technology and Information Technology, which can be expanded to a larger group of systems to produce a complete, SMART communicating product.

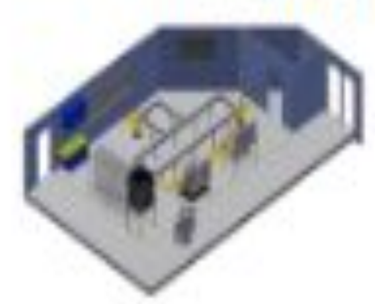
Desiring a way to design a manufacturing system plan, build production infrastructure, automate system, & collect / visualize data.

Requirements Matrix

Req #	Requirement	Description	Test
Work Room Area Requirements			
1	Max Working Area	The max dimension of the total working area is 612 square feet.	Measure the dimensions with a tape measure to get size requirements.
3	Max Conveyance Area	The max dimension of the total conveyance area is 200 square feet	Measure the dimensions 3 feet from any permanent structure
Shuttleworth Requirements			
4	Operating Voltage	Shuttleworth requires a power supply of 208 VAC, 50 - 60 Hz	Use a digital multimeter to measure the power supply.
5	Operating Current	Shuttleworth requires a max current supply of 15A.	Use a digital multimeter to measure the power supply.
7	Motor Size	supplies 1/2 HP motor sizes.	Use a force gauge to determine the necessary motor size.
9	Max Speed	Shuttleworth delivers a max speed of 5 fpm	Measure mover speed with a speedometer.
11	Repeatability	Shuttleworth has a repeatability of +/- 0.5mm.	Test repeatability using a precision sensor measurement tool.
12	Payload	Shuttleworth contributes a payload up to 15lbs with pallet.	Test the payload capability using test various weights.
Product Production Requirements			
16	Product Height	The product will have a minimum height of 6"	Measure the height with a tape measure to get size requirements.
17	Product Weight	The product will have a weight of no more than 2kg or 4.4lbs.	Measure product weight using a scale.

Experimentation / Concepts Exploration

MagneMotion → Rockwell Automation ← Shuttleworth



MagneMotion

Strengths:

- Future of Conveyance
- Industry 4.0 (IoT)
- Leading Edge

Weaknesses:

- Cost / Availability

Rockwell Automation

Strengths:

- Industry Dominant
- Purdue Connections
- High Value Skills
- Focus On SMART Manufacturing
- Seamless integration

Shuttleworth

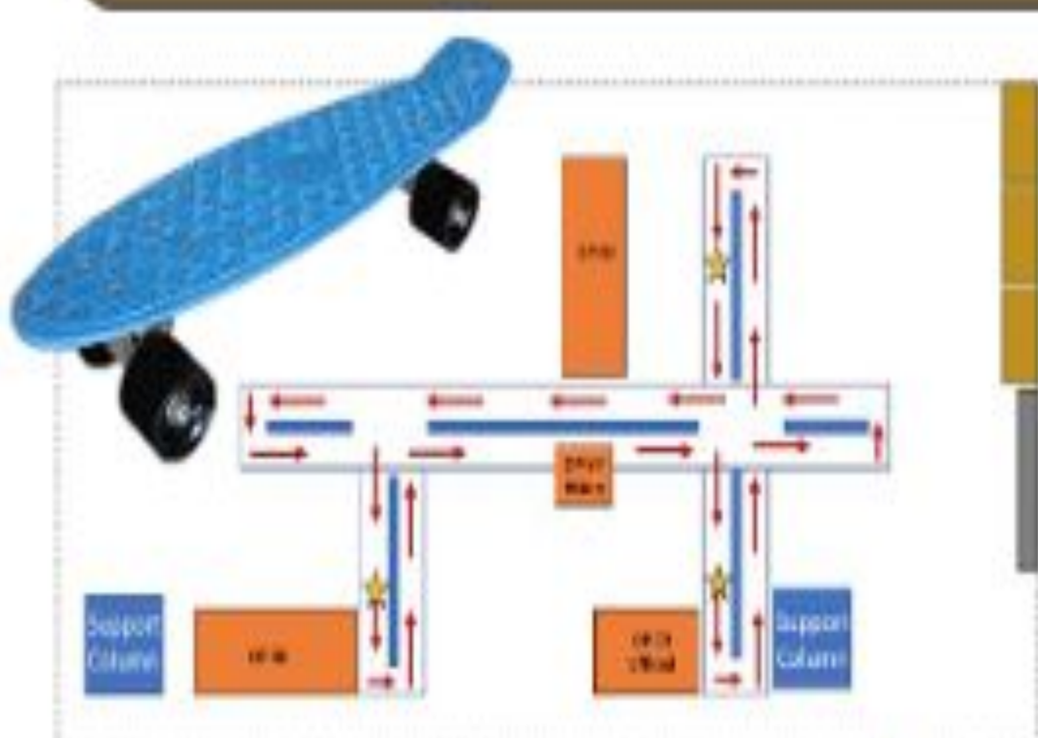
Strengths:

- Slip-Torque Technology
- VFD Controlled
- Availability & Adjustment

Weaknesses:

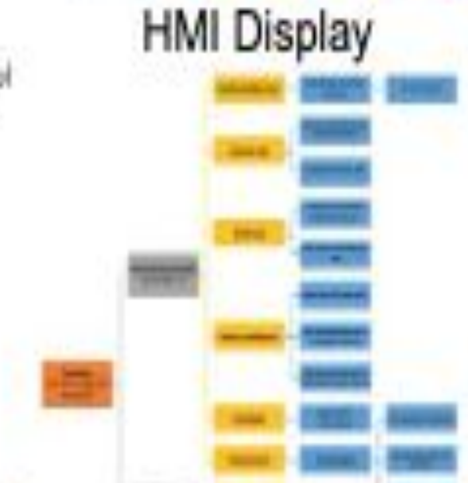
- Current Industry Technology

Final Design



Conveyor Layout

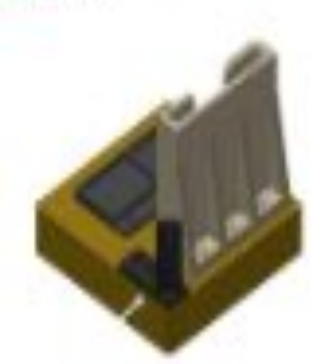
HMI Display



Controls Layout

Material Handling

Vision Inspection



Pallet Design

Safety Integration

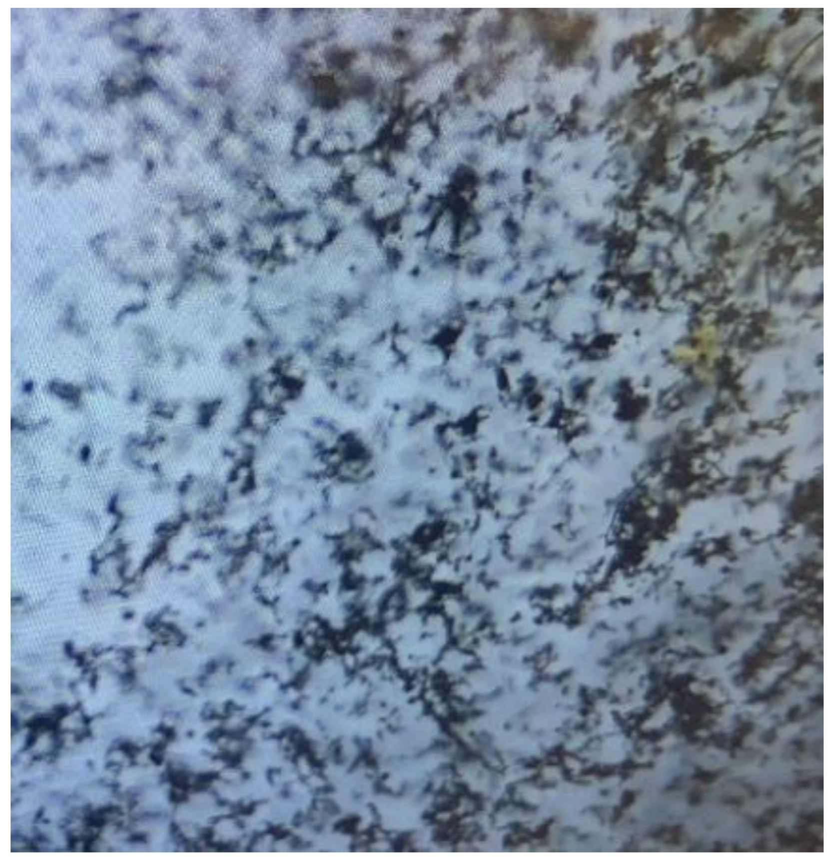
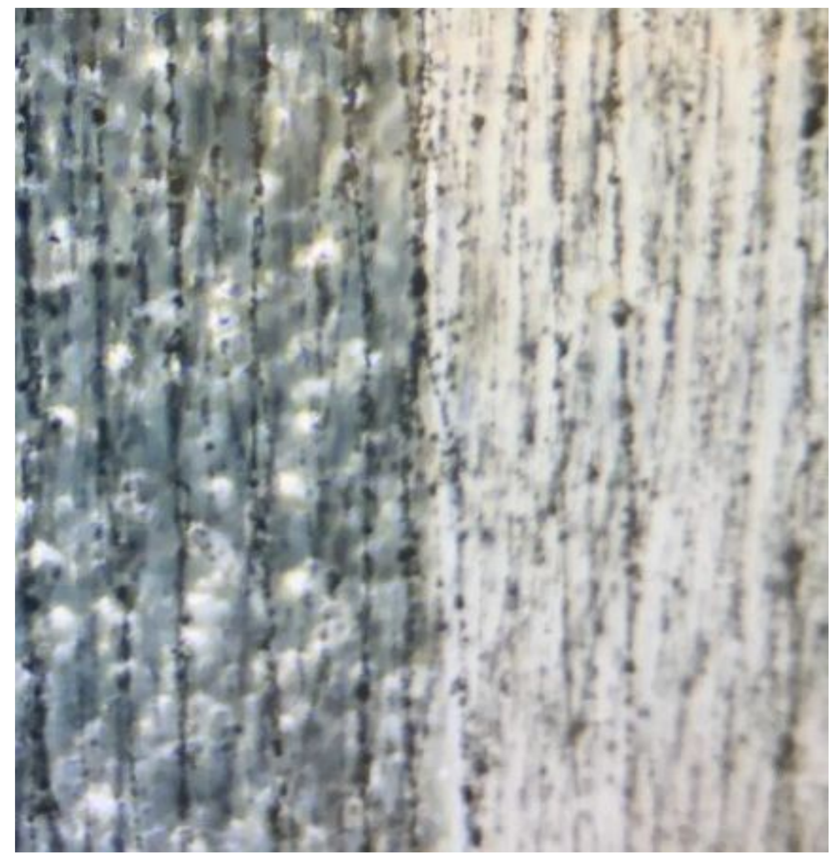
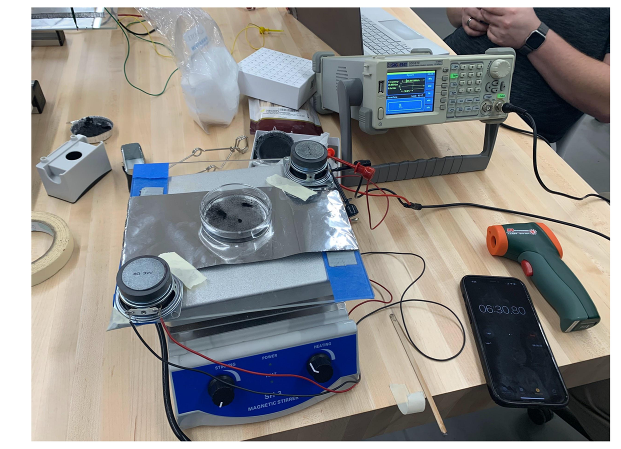
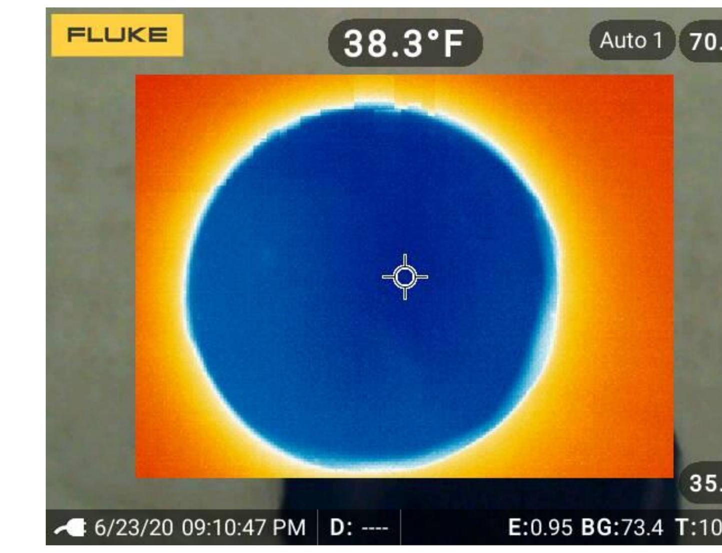
Failure Mode and Effect Analysis

Key Process Step	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN	Actions Taken
FMEA - Failure Modes and Effective Analysis									
Automation / Controls									
Programmable Logic Controller	Communication Loss	Unfunctional System	1	Improper Power Cycle	3	Follow lab regulations and use e-stops in emergency	2	6	The PLC is placed in a locked control panel
Data Display	ThingWorx not complete	Data not displayed in newest industry display technology	2	Not Licensed	2	Factorytalk View can display PLC data	1	4	Data display pages created on Factorytalk
Visual System	iPads Break	Operator unable to control station	1	Operator Error	1	Factorytalk Viewpoint can hook to any device on network.	1	1	And device on network is able to log into control screen if given permission
Mechanical / Material Handling									
Conveyor System	Pallets can launch off conveyor	Workers can be injured	3	Lack of air regulators on pallet pushers	1	Inspect air pressure	2	6	Blocks have been created out of extruded aluminum
Material Handling Station	Unsure of what materials the OPs need	Will cause stoppage and will disrupt flow	1	There is not an indicator to inform operator	2	Material data collection	2	4	Stack Lights have been mounted and color coded to assist operator
General									
Safety	Clothing gets caught in machinery	Loss of life or limb(s) for workers	2	loose/baggy clothing or jewelry, long hair hanging down	1	Shut down system and deal with caught clothing	2	4	hang warning signs that state jewelry & loose clothing is forbidden while long hair must be pulled back

Testing

Step	Test	Details	Outcome
General Automation & Mechanical Testing			
1	Motor Control	The PLC controls the VFDs which ramp the drive motors to proper operating speed	All VFDs, drive motors, and drive shafts operate correctly
2	Sensor and HMI Inputs	The PLC reads all of the conveyor and operation sensors	All of the sesors are reading to the PLC
3	Output Results	The PLC and HMIs make the proper inputs trigger the proper outputs	The pallet stops, pushes, plungers, and chains are all operating correctly
4	Pallet Cycle	A pallet will cycle the entire track without a problem	A single pallet effectively travels around the track
Production Testing			
5	Operation Stock Testing	The inductive proximity or photoelectric sensors measure the level of component supply.	The visual display and stack lights ensure that materials are stocked
6	Nutrunner Torque	The Ingersoll Rand Nut Runners provide an accurate torque to assemble the board.	The INSIGHTqc output the correct torque rating for each component
7	Takt Time	Each operation is timed with a stopwatch to develop base takt time	The average takt time for each operation was calculated and responsibilities were assigned accordingly
8	Production Amount	A timer will be used to measure how many boards can be assembled in 1 hour	The PLc caculates "Boards per Hour" based on takt time

- Group photo - .PNG or .JPG file; image must be at least 500 pixels wide and tall; larger is better, but file must be under 10MB
- Project summary - explain your project in 255 characters or less.
- Project description - describe your project with as much detail as you like; no character limit.
- Video presentation of project - explain the problem you solved, any challenges along the way, and your solution.
  - Very important: include “PRESO” in this video’s title.
  - Video can be no longer than 5 minutes long and must be provided as a YouTube link; if filming with a smartphone, please hold it sideways (landscape orientation); it is not necessary to include any Purdue branding, but if you do so, please follow University brand guidelines, see https://marcom.purdue.edu/our-brand/ for details.
- Video demonstration of the project - a demonstration of your solution.
  - Very important: include “DEMO” in this video’s title.
  - Video can be no longer than 5 minutes long and must be provided as a YouTube link; if filming with a smartphone, please hold it sideways (landscape orientation); it is not necessary to include any Purdue branding, but if you do so, please follow University brand guidelines, see https://marcom.purdue.edu/our-brand/ for details.
- Sponsor URL - students will provide the URL for their sponsor’s website.
  https://prf.org/
- Sponsor logo - students will select their sponsor from a drop-down list.
  Purdue Research Foundation
- MS Teams meeting - create and provide link to a Microsoft Teams meeting that you create for April 27, 2023, 1pm-4pm (Eastern).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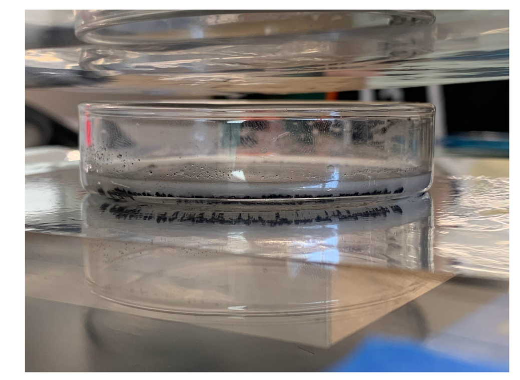

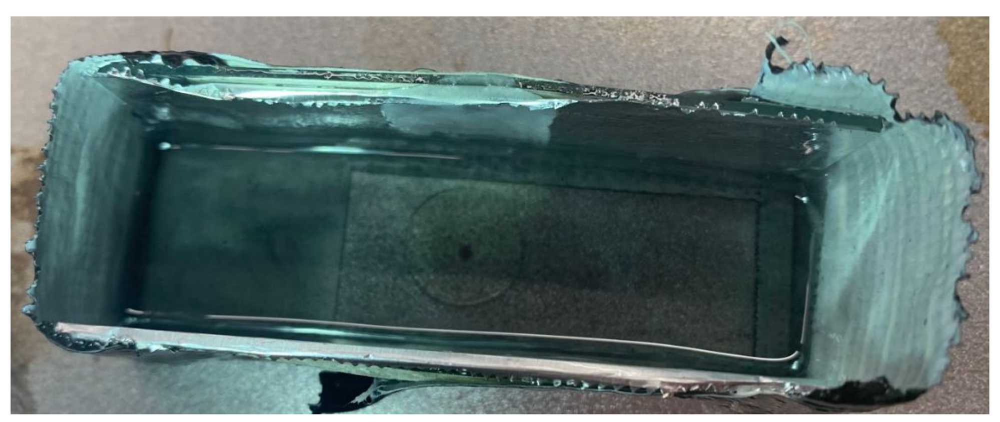

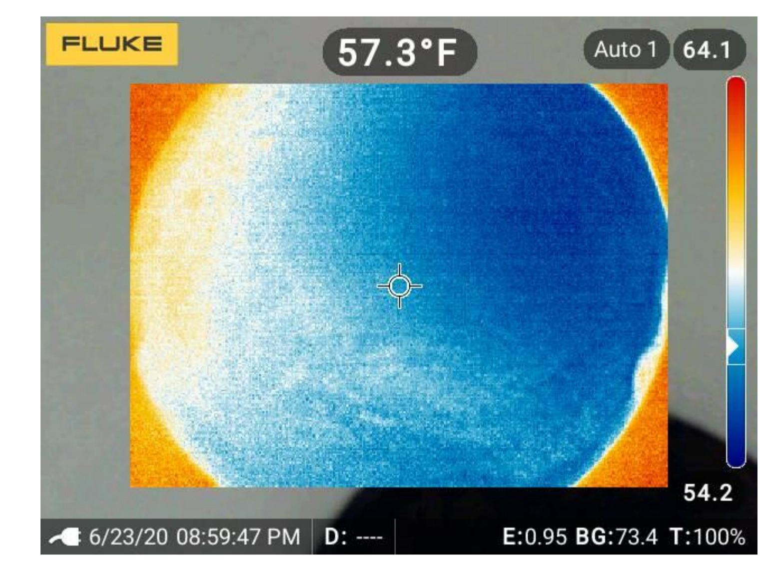
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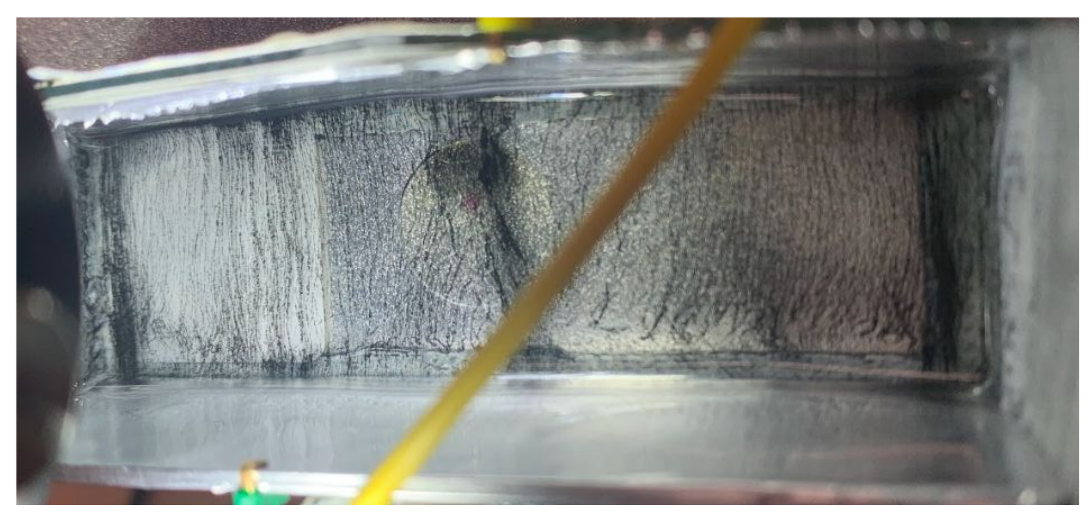
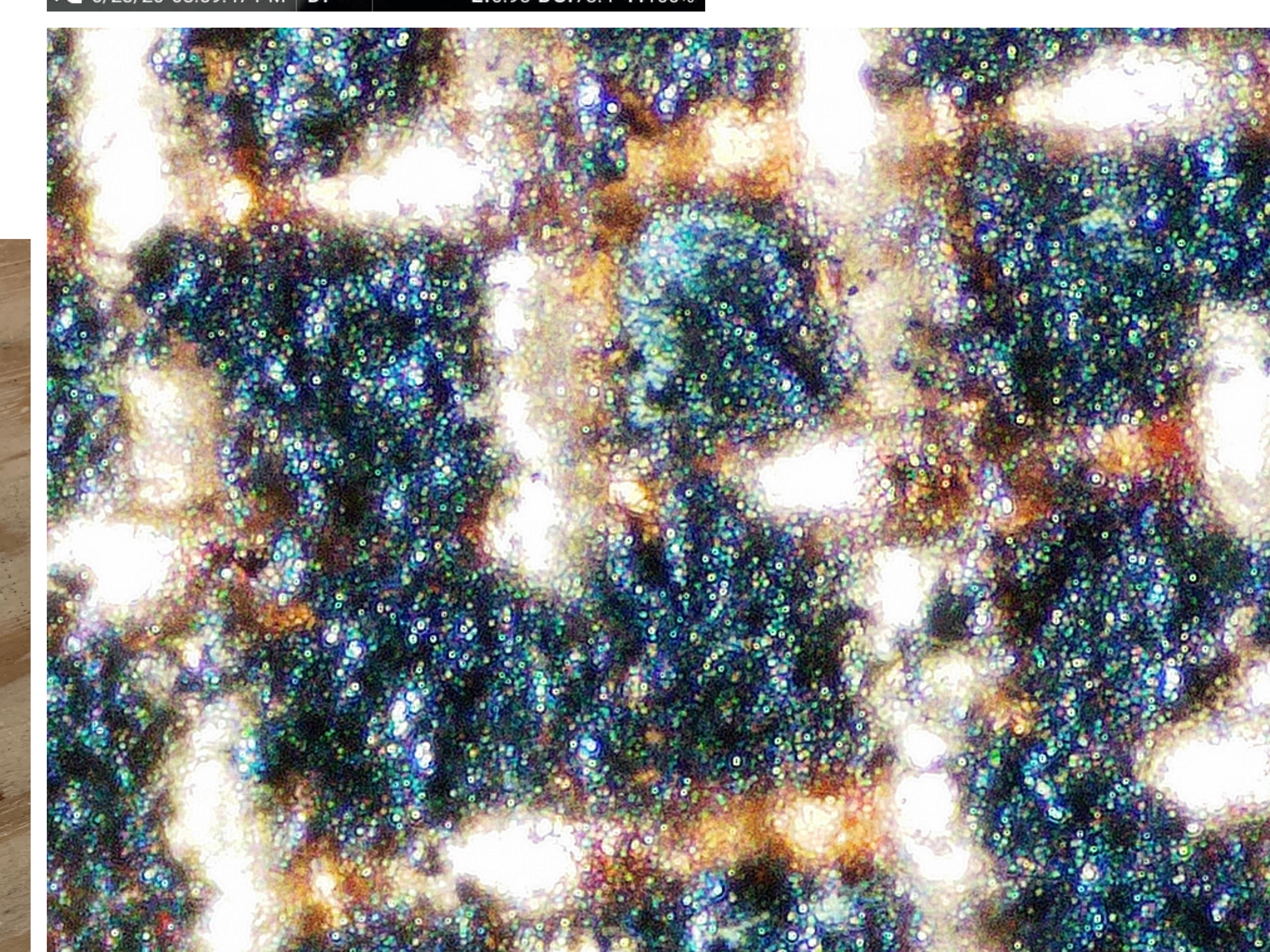
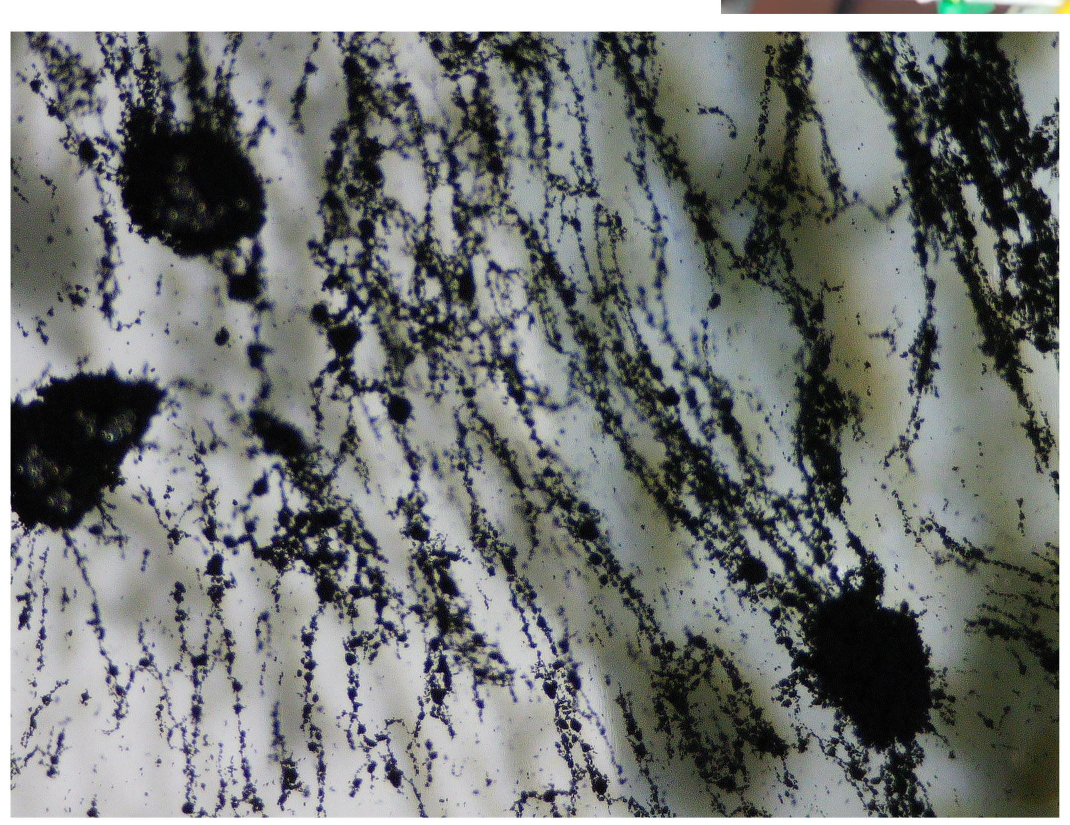

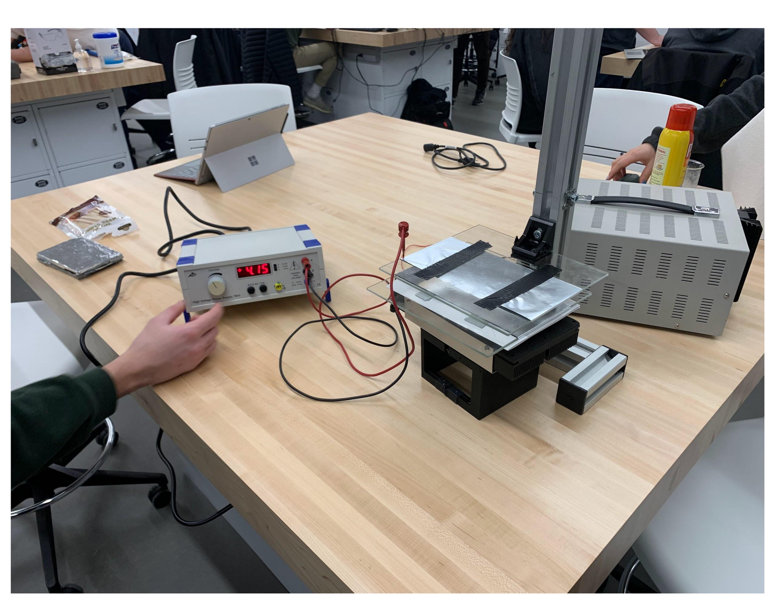

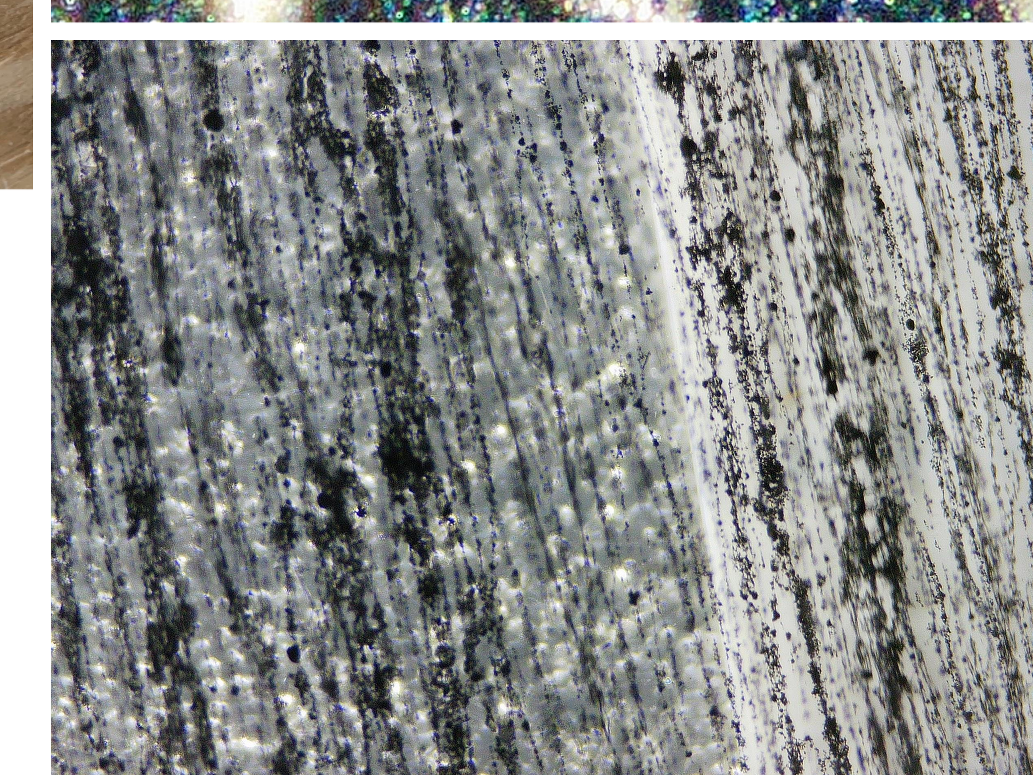

Video Demonstration

1-2 V

The CNTs are still at 1V then once the voltage goes over 2V the CNTs start to shake.

3-4 V

At 3V the CNTs begin to align vertically then at 4V the CNTs make prominent lines.

5-↑ V

As the voltage increases past 5V the current passes through the CNT lines it creates a short between the aluminum plates.