NAU FUME HOOD FINAL PRESENTATION

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PROJECT DESCRIPTION

- The Project is to design a fume hood for the biomechanics lab that will be attached with an provided exhauster to be used in Carbon Fiber experiments to filter the particles produced during the experiment.
- Dimensions: 4ft wide - 2ft deep – 3 ft long.
- Filtering system: the filter is an essential component required by the client, which will be attached to the exhauster.
- Additional Features: Pressure transducer – Visual display

ENGINEERING REQUIREMENTS

- Engineering Requirements determined from Customer Needs.
- Safe for common use at NAU's Biomechatronics Lab
- Eliminate the threats of Carbon Fiber epoxy fumes and particulates produced during sanding and cutting operations.

Table 1: Engineering Requirements

Engineering Requirements	
Requirement	Units of Measure
Dimensionality	2x4x3 feet
Weight	< 80lbs
Volumetric Flow Rate	300-395 CFM
Air Velocity	4000 FPM
Pressure Drop	< 2 kPa
Maneuverability	Transportable within building
Durability	200 Kpsi
Filter Assessment	Seconds
Usability	Compatible with EBR 50 Exhauster
Particulate Capture	0-80% Max capacity (lb/ft^3)

TOLERANCES

- Tolerances determined based on relationships between pressure, velocity, and volumetric flow rate through the system.

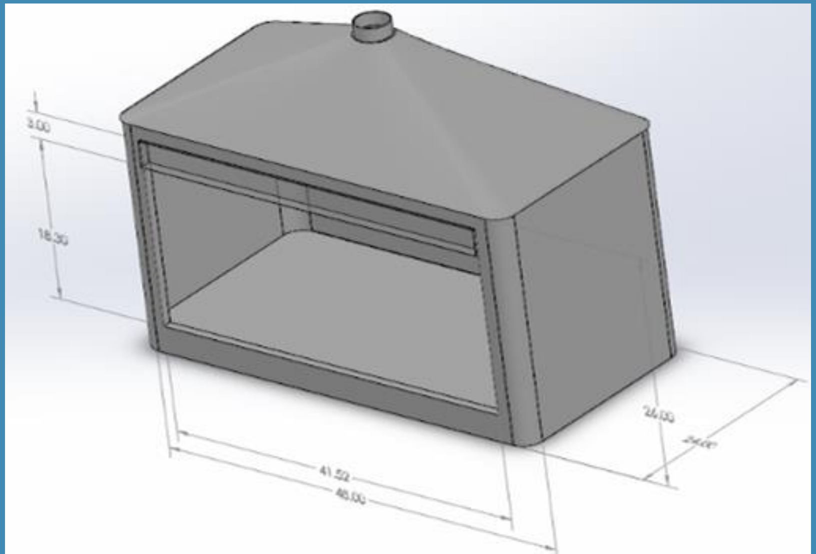

Figure 1: Dimensioned CAD Model

Table 2: Tolerance Measurements

Tolerances	
Requirement	Units of Measure
Dimensionality	0.25x0.25x0.25 feet
Weight	+/- 5lbs
Volumetric Flow Rate	+/- 5 CFM
Air Velocity	+/- 5 FPM
Pressure Drop	< 0.25 kPa
Maneuverability	Transportable within building
Durability	+/- 5 Kpsi
Filter Assessment	1/60 Seconds
Usability	Compatible with EBR 50 Exhauster
Particulate Capture	+/- 15% Max capacity (lb/ft^3)

COMPUTATIONAL ANALYSIS

- $Required\ Air\ Flow:\ \ Q = \frac{A}{v} = \frac{3ft^2}{2000\ fpm} = 7.5\ * 10^{-4}\frac{ft^3}{min}$ [eqn. 1]
- $Velocity\ of\ Air\ in\ Duct:\ \ v = \frac{Q}{A} = \frac{0.00075\frac{ft^3}{min}}{\frac{\pi}{4} * 0.4in^2} = 8.6\ \frac{ft}{min}$ [eqn. 2]
- $Area\ of\ Hood\ Opening:\ \ 1.5ft\ * 2ft = 3ft^2$ [eqn. 3]

RISK ANALYSIS

Table 3: Top 10 most important failure criterion from simplified FMEA

Part # and Functions	Potential Failure Mode	Potential Effect(s) of Failure	Potential Causes and Mechanisms of Failure	RPN	Recommended Action
Filter	Wear	Erratic operation (no suction)	Poor Maintenance (Clogge	2	Remove/clean filter after each use
Filter Slide	Deformation wear (cracking	Poor appearance	Poor maintenance	1	Make sure filter slides with ease into housing
exhaust hose	Abrasive wear	Suction loss (noise,flying debri	Poor Maintenance/design	9	Use a hose with smooth walls instead of ribs
Exhauster	Thermal Fatigue	Erratic operation (no suction)	Overstress (overuse)	8	Do not run exhauster for extended lengths of time
Worm Drive Clamp	Deformation wear	Poor appearance	Assembly Error	1	Ensure worm drive is securely fastened to fume hood
Exhauster Plug	Wear	Erratic operation (no power)	poor maintenance	5	make sure exhauster plug is functionable and safe for operation
Fume Hood Chamber	Deformation Wear	Poor Appearance	Poor maintenance	3	Watch for cracks and deformities in the fume hood
Filter	Abrasive wear	Flying debris/Erratic Operation	thermal deformation from c	7	replace the filter as necessary when signs of wear and tear are observed
Filter Slide	Deformation (thermal)	flying debris/bad appearance	thermal deformation from c	5	replace plastic slide as deformations are observed
Hood Chamber	Corrosion	Inability to operate	poor maintenance	10	Ensure carbon Fiber does not corrode the selected fume hood material

- From this risk analysis we can prove that our biggest potential failures arise from the fume hood chamber, the exhauster fan, and the exhaustion hose.
- We are focused primarily on the fume hood chamber aspect of this capstone. If the hood chamber design is unable to provide adequate suction power or falls apart it would cause usability issues for the device. As such we are less focused on the failures of the exhauster fan since this was done previously in a different capstone.

RISK ANALYSIS- CONTINUED

Severity Standard

- Each of the top 3 potential failures would render the fume hood inoperable. Failures would allow harmful particulates and fumes to enter the atmosphere in the room proving harmful to users within the lab.

Cause of Failure

- Each part failed for different reasons.
- The Exhauster hose has a potential to fail from abrasive wear as sharp carbon fiber particulates would cut and scrape the hose walls causing tears and suction loss.
- The exhauster has potential to fail due to thermal fatigue (overheating) due to prolonged usage times.
- Lastly, the hood chamber would fail due to potential corrosion on the walls of the chamber. Carbon fiber of itself is prone to galvanic corrosion and could transfer this tendency to the chamber materials. [1]

RISK MITIGATION

- From our risk analysis we came up with some possibilities that would eliminate or mitigate the main potentials causes for error within the system.
- As mentioned previously, when coupled with a Carbon Component, both Aluminum and plain Steel are susceptible to galvanic corrosion. This would corrode the hood chamber, while also rendering it useless. To mitigate this potential failure we are looking into more carbon friendly hood chamber materials. This includes moldable plastics (which would be a cheaper option to metals), titanium (with it's alloys), or even stainless steel. However, stainless steel would be more susceptible to pitting or crevice corrosion [1].
- We hope to eliminate cutting of the exhaust hose by first testing the current hose that accompanies the exhauster to see exactly how it stands up to sharp carbon fiber particles and fumes. The next step would be to replace the hose with a more durable (smooth walled) hose that could be made of a compatible metal.
- To mitigate the risk of thermal fatigue and overheating we discussed, with Dr. Lerner, a relay device that would shut the exhauster fan down until it reached a cooler operating temperature. We also assume that the exhauster fan may already have this technology built in and this assumption requires further testing and analysis.

TESTING PROCEDURES

- To conduct further analysis and study we hope to be able to test our exhauster and hood chamber with colored smoke or powder. This test would allow our team to conduct a series of tests including: suction power, flow rate, velocity, and particulate capture efficiency.
- Testing could be done anywhere, but we hope to test at NAU's Biomechatronics lab to get a clearer picture of how and when this device will operate in its primary habitat.

ME486 PROJECT SCHEDULE

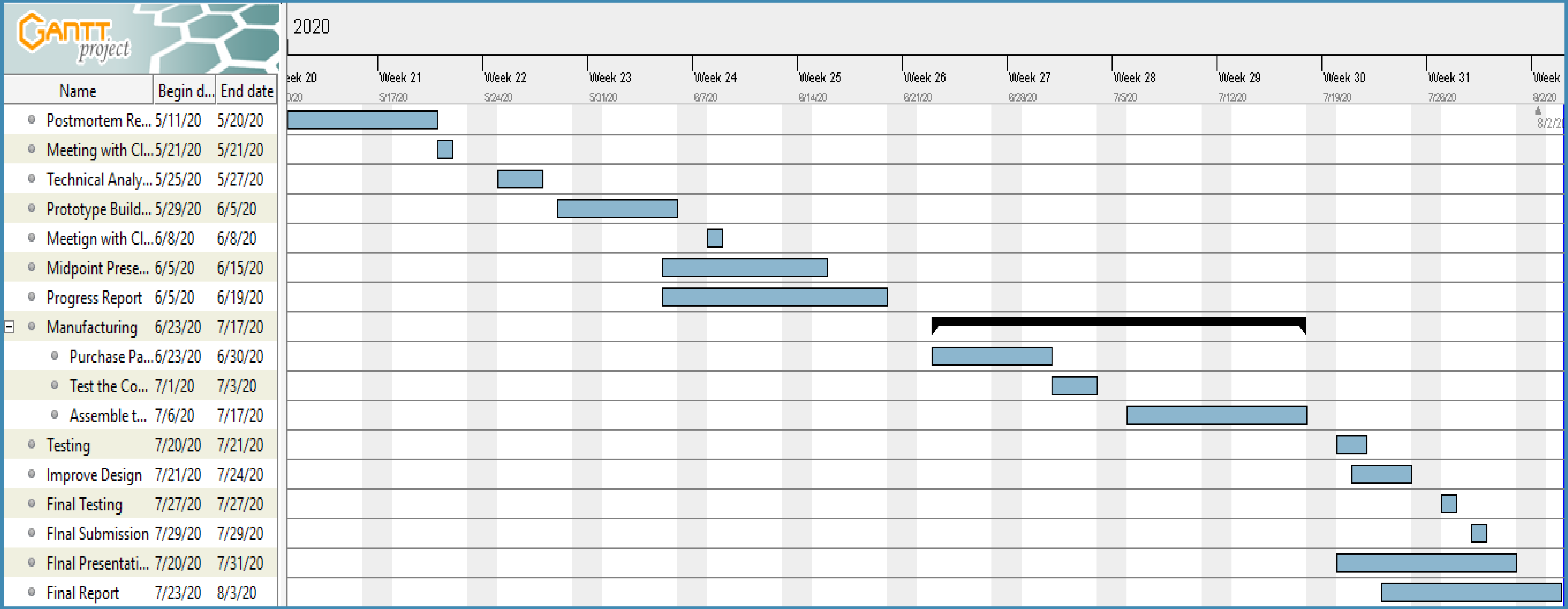

Figure 2: ME 486 Gantt Chart Schedule

BUDGET ANALYSIS

Table 4: Current Budget Analysis

Total Budget	$400
Anticipated Expenses	$400
Actual Expenses to Date	$0
Saved Expenses	$400
Remaining Balance	$400

REFERENCES

- Bossard, "Galvanic Corrosion in Carbon Fiber Materials," 19 December 2014. [online]. Available: https://provenproductivity.com/galvanic-corrosion-carbon-fiber-materials-2/#. [Accessed 24 April 2020].