Thermodynamics Demonstration Unit 1B
Power Generating Turbojet Engine

HARDWARE REVIEW # 2

EGR 486C-01

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Introduction

The purpose of this report is to demonstrate the status of the project and how much work remains. Manufacturing and designing the power generating Brayton Cycle requires the team to break down each component and assign the responsibility to a team member. In this report, each component will be analyzed and described further to visualize the purpose of the part.

Casing System

At the time of this report, the casing system is in the process of being printed at the NAU Rapid Lab. The casing was required to be separated into multiple sections because of the length restriction of the printers. The section of the casing will be connected using ¼" bolts and locking nuts to minimize the pressure loss over the connections. Updates have been made to the design to accommodate issues that arose, such as problems with blade installment. The most current design, and file sent to the Rapid Lab, is located below in Figure 1. The compressor section of the casing contains viewing sections to show students the blades moving the air. These viewing sections will be covered with a clear plastic to prevent pressure loss. Moving forward for the casing system would require a mounting system for the casing onto a portable cart.

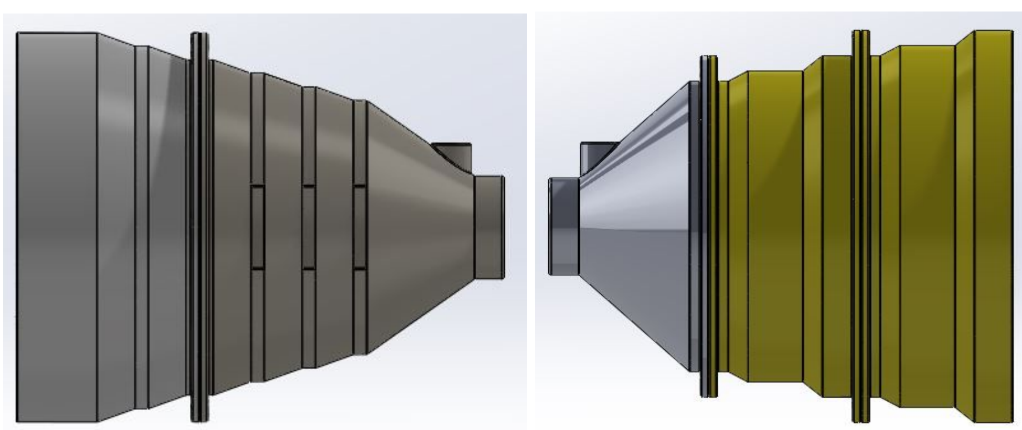


Figure 1: Compressor and Turbine Casing

Cart System

A portable project is necessary to allow for the movement between several class rooms. A cart must be selected and purchased that allows the carrying of the project and the air compressor necessary for ignition. Following the purchase of the cart, it will be necessary to assemble a main power cable that attached all power sources to one location to allow for quick movement. As of this hardware review, the cart has not been purchased and will be purchased when the blades have been attached to the shaft.

Ignition System

An operating power generating Brayton Cycle requires the input of a working fluid into the compressor section to allow for power output. All air compressor components that the project requires have been purchased. The plan for the ignition system is a simple ball valve, seen in Figure 2, will be regulating the flow through PVC piping into an air diffuser. The purpose of the diffuser for the project is to diffuse the single burst of air coming from the ball valve to a larger area. This is to prevent the air burst from damaging the plastic blades. As of now, the diffusion system has not been designed, but will be completed soon.

Figure 2: Air Compressor with Ball Valve

Printing Blades

All blade stages have been printed from the NAU Rapid Lab, as seen in Figure 3. Moving forward requires the application of lacquer to all blades to increase structural support and increase life cycle. Once the lacquer process has been applied to all blades, they will need to be mounted onto the keyed shaft.

A ball bearing casing has been designed for the stator sections and is awaiting pick up. Using epoxy on the casing to the radial ball bearing will ensure a secure fit. Once the radial ball bearing is able to be mounted onto the shaft, the casing can be fully assembled.

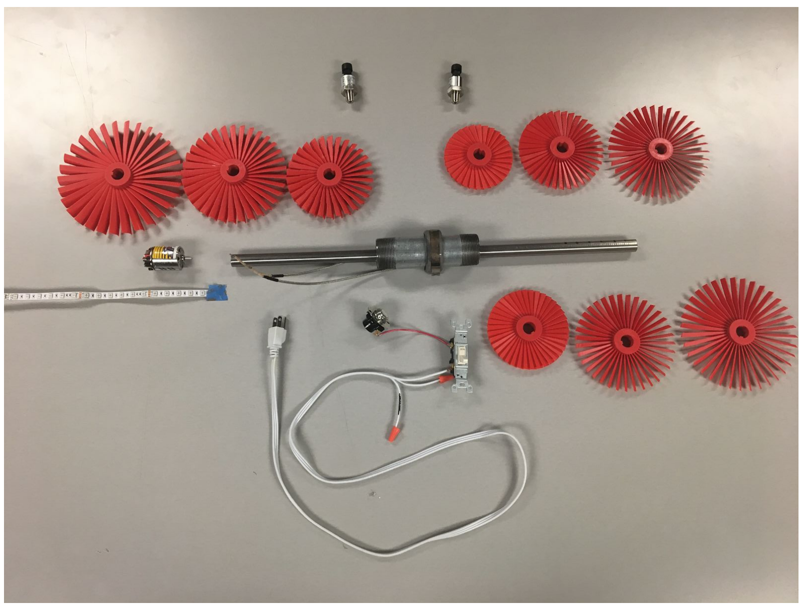


Figure 3: Current Assembly with Blades

Heating System

The heating element for the power generating Brayton Cycle is fully operable and requires minimal work to complete. Safety is paramount for the heating band, therefore the wiring will be organized so no exposed wire is present. A figure of the testing of the heating section is shown below in Figure 4. Aluminum tubing has been purchased for the full housing of the heating system; once fully insulated the system will be safe to touch and operate reliably. Additionally, insulation tape will be wrapped around both the heat sink and the casing to prevent melting of plastic. Moving forward requires the implementation of thermocouples into the system to allow the data acquisition of temperature points. Thermocouple wires have been acquired, and the research necessary for the data acquisition has begun.

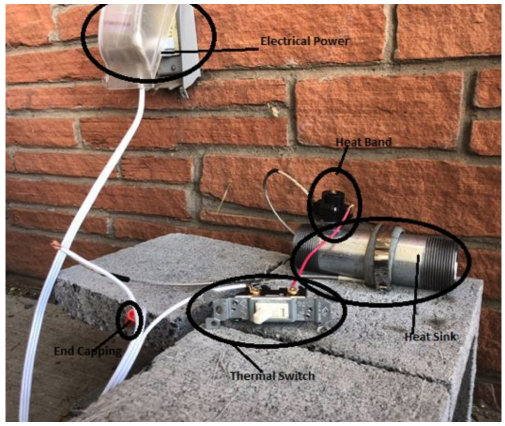


Figure 4: Operating Heating System

Pressure System

The system that requires the most data acquisition interface is the pressure system. Currently, the team is behind schedule due to purchasing issue for the pressure transducer. Moving forward for the pressure system, requires proper knowledge of resolution between all components and the user interfaces. This resolution is specific to the voltage produced from the change in pressure, the data acquisition utilizes the data and processes it into working data. After all purchasable materials have been acquired, it will be necessary to write up code in Labview that allows for the quick implementation of temperature and pressure readings.

Power Output System

All components of the power output system have been purchased, the printed bearing casing is awaiting print. Assembly has begun for the power output system; DC power input (from the motor) into a LED controller (with color remote) to power the LED strip. LED bulbs may be switched out from the LED strip to allow a simple breadboard to allow DC input and built housing.

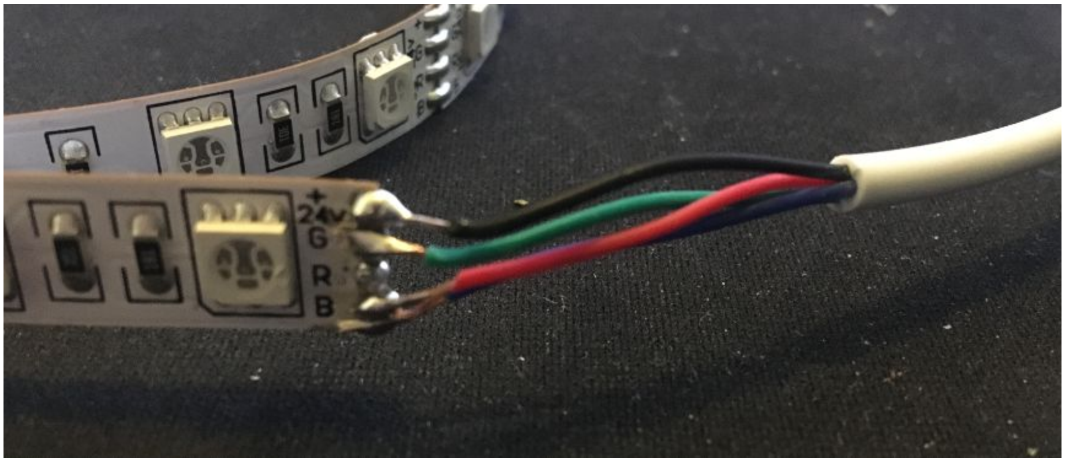


Figure 5: RGB Wire to LED

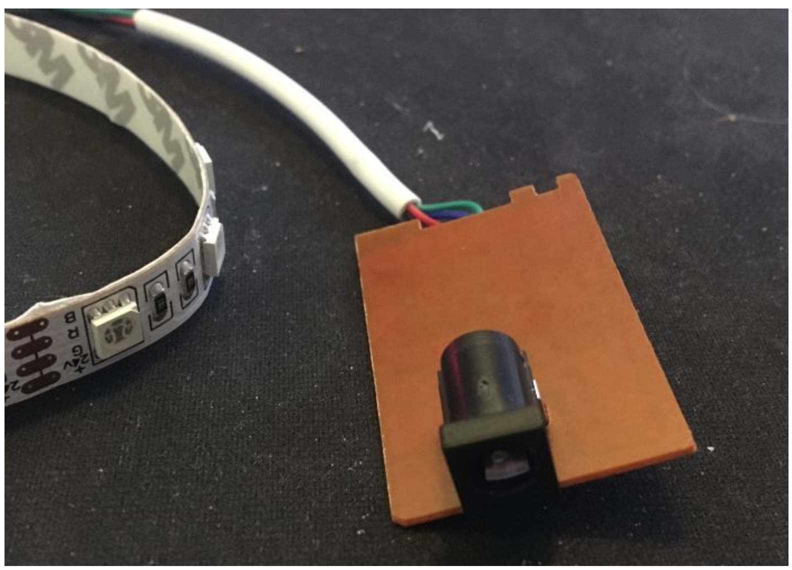


Figure 6: DC into LED Controller

Work Breakdown Structure

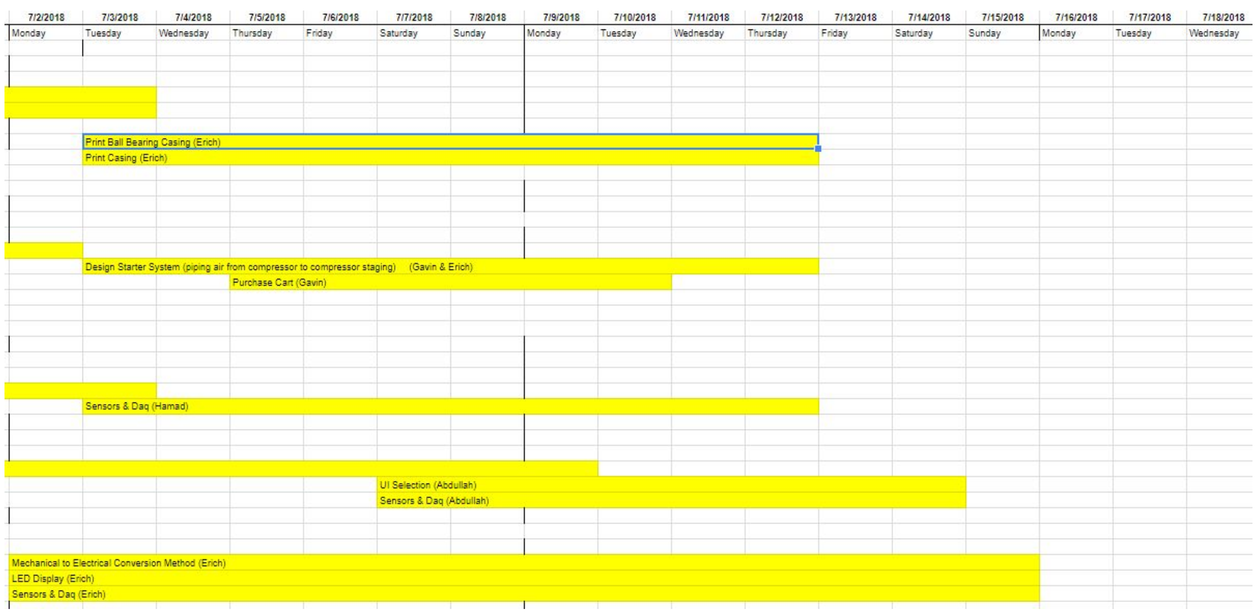
Table 1: Work Breakdown Structure (88%)

Tasks for Team Members	Task Completed	Tasks in Progress	Tasks to Complete
3D Print (Erich)	Ball Bearing Casing Designed CAD CAD update Keyed Shaft purchased Blade Staging Printed (x9)	Printing Bearing Casing Printing Turbine Casing Printing Compressor Casing	Updates (Pending)
Casing (Gavin)	Case Shape designed Material Selected Purchase Bolts (x12)	Plywood Construction Purchasing Cart	Assemble Casing System
Heating System (Hamad)	Heat Band purchased Thermal Fuse Purchased Heat band power input built Power Switch assembled Thermocouple acquired	Assemble safe housing and wiring DAQ acquisition	Thermal Insulation Wire Management with cart
Pressure System (Abdullah)	Pressure Transducer purchased Purchase Wire for pressure systems p-V & T-s diagram for power output ranging from 50 - 100 Watt	Labview acquisition	Labview Acquisition
Work Output System (Erich)	LED strip purchased Brushless Motor Selected Motor hub designed and currently printing RGB Wiring purchased	Assemble Wiring system	LED Display Housing Power Check System
Ignition System (Gavin)	Air Compressor acquired Valve Purchased Tubing purchased	Air Diffuser Design	Implementation of air compressor to cart

GANTT Chart

Utilizing the Work Breakdown structure, the Gantt chart was updated to represent the current progress of the project. There is a current delay for the pressure system, where an ordering issue occurred. This minor setback will not set the current progress off track, there has been time allotted per week to address issues as such.

Table 2: Gantt chart



Budget

The project's budget is provided below in Figure 7. Only a few more small purchases, cart and parts for mounting, remain to be purchased. The team is currently below budget, and on track to complete the project in time.

	Vendor	Part #	Part Name	Qty	Description	Cost Per Unit	Total Cost + Tax
Structural/ Data Collection	McMaster-Carr.com	1	Keyed Shaft	1	3/4" Dia, 2 ft long Keyed Shaft	$ 47.50	$ 41.68
	HomCo	2	Ball Bearings	3	Radial Bearings	$ 4.95	$ 14.85
	Home Depot	3	Pressure Transducer	2	Pressure Collection	$ 49.00	$ 119.98
	Home Depot	4	Pressure Transducer Wire	2	Wiring for Transducer		
	Home Depot	5	Thermocouple Wire	2	J Type Thermocouple Wire	$ 4.00	$ -
	Home Depot	6	Duct Tubing	1	Sleeve Over Heating Section	$ 10.48	$ 10.48
	TransducersDirect.com	7	Bolts	12	1/4" Diameter, 1" long	$ 0.63	$ 7.56
		8	Nuts	12	1/4" Locking Nuts	$ 1.18	$ 14.16
		9	Washers	12	1/4" Diameter	$ 0.10	$ 1.18
	Home Depot	10	Wires				
		11	Wire End Caps		Plastic Wire connectors	$ 2.58	$ 2.58
					Total	**$ 120.42**	**$ 212.47**
Heat	Home Depot	12	Heat Sink	1	1.5" x 5" Steel Pipe	$ 5.99	$ 6.93
	Tempco	13	Band Heater	1	Collar Heater	$ 32.30	$ 45.09
	Grainger	14	Thermal Fuse	1	Temperature Regulator	$ 17.60	$ 29.57
	Home Depot	15	Switch	1	Emergency Shutoff Switch	$ 0.69	$ 0.83
	Home Depot	16	Thermal Tape	1	Thermal Tape for Insulation	$ 4.98	$ 4.98
					Total	$ 61.56	$ 87.40
Compressor	CPOOutlets.com	17	Air Compressor	1	6 gal 150 PSI Compressor	$ 89.00	$ 96.90
	Home Depot	18	Recoil Hose	1	25 ft Compressor Hose	$ 14.98	$ 16.10
	Home Depot	19	Ball Valve	1	Compressor Connector	$ 8.98	$ 9.70
					Total	**$ 112.96**	**$ 122.70**
Power		20	Brushless DC Generator	1	Power Generation	$ 20.00	$ 20.00
	SolidApollo.com	21	LED Light Strip	1	Light Strip	$ 14.00	$ 15.00
					Total	**$ 34.00**	**$ 35.00**
3D Prints	NAU	22	Comp Casing 1	1	3D Print	$ 15.00	$ -
		23	Comp Casing 2	1	3D Print	$ 15.00	$ -
		24	Turbine Casing 1	1	3D Print	$ 20.00	$ -
		25	Turbine Casing 2	1	3D Print	$ 20.00	$ -
		26	Comp Blade 1	1	3D Print	$ 10.00	$ -
		27	Comp Blade 2	1	3D Print	$ 10.00	$ -
		28	Comp Blade 3	1	3D Print	$ 10.00	$ -
		29	Comp Blade 4	1	3D Print	$ 10.00	$ -
		30	Comp Blade 5	1	3D Print	$ 10.00	$ -
		31	Comp Blade 6	1	3D Print	$ 10.00	$ -
		32	Turbine Blade 1	1	3D Print	$ 10.00	$ -
		33	Turbine Blade 2	1	3D Print	$ 10.00	$ -
		34	Turbine Blade 3	1	3D Print	$ 10.00	$ -
					Total	**$ 160.00**	**$ -**
					Project Total	**$ 488.94**	**$ 457.57**

Figure 7: Project Budget

Conclusion

Overall, the team is on track to complete the project in the allocated time. There are minor adjustments the team needs to make, such as designing a mounting system. The team is confident that the system will operate as intended and provide aid to a thermodynamics classroom. The safety and considerations of the student have been incorporated into the design. The team will continually work on the individual subsystems of the project in order to complete the project on time.

Appendix

CAD Drawings

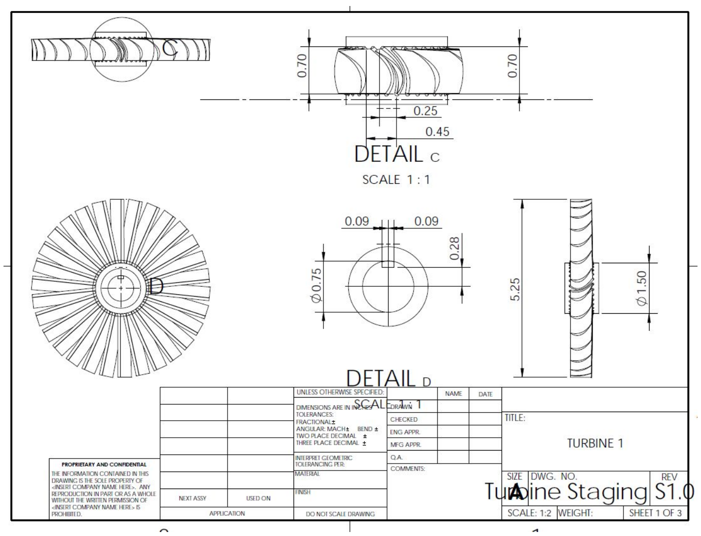


Figure 8: Turbine 1 CAD

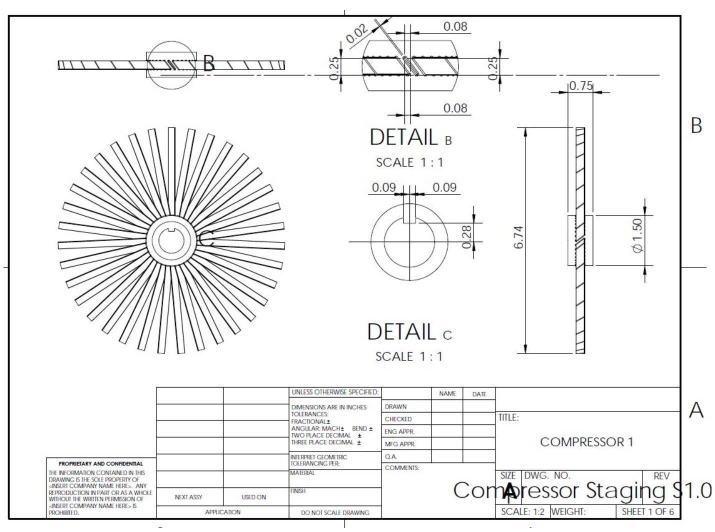


Figure 9: Compressor 1 CAD

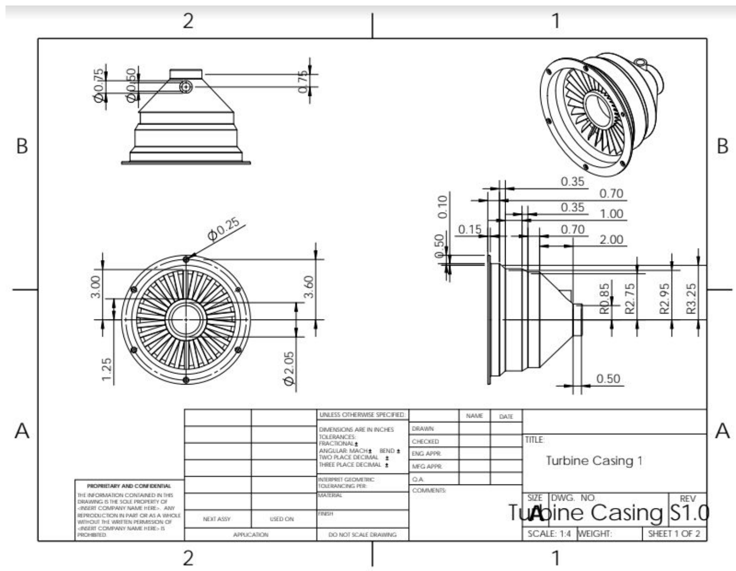


Figure 10: Turbine Casing 1

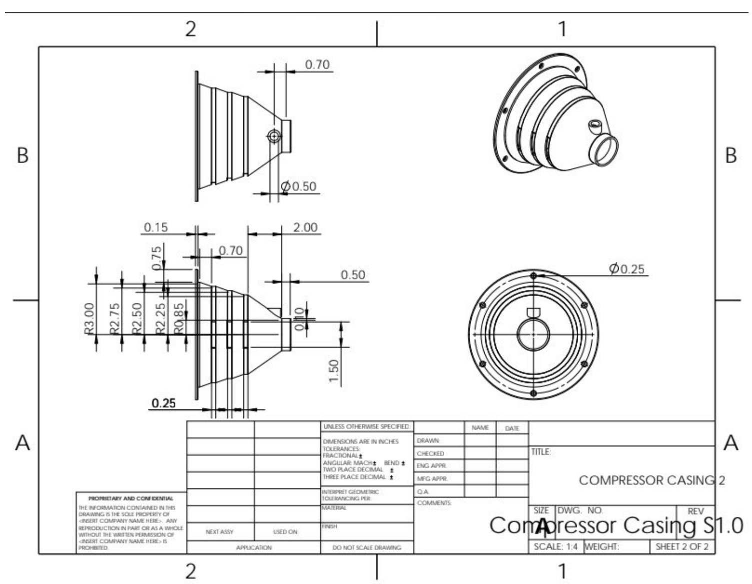


Figure 11: Compressor Casing 2

Exploded View

Figure 12: Exploded View