Testing Proof
Thermodynamics Demo Unit 1B
August 3, 2018

Table 1: Original Engineering Requirements

Engineering Requirements	Target	Units	Justification
Work Output	20 Watt	$Watt$	Production of power from turbines will turn on a light bulb connected to the system.
Aerodynamic	>.3	C_d	Minimizing aerodynamic drag will increase the power produced from turbines
Thermal Capacity	100	K/m^2	Implementation of a heat exchanger, will provide the data for interactive graphs
Volume	<.5	m^3	Constant volume measurements for each process of cycle is required for P-v diagrams
Data Acquisition	Pressure and Temperature	Pa, K	To create a realtime chart for T-s & P-v diagrams to simulate a Brayton Cycle

Work Output

The LED strip shorted and was unable to operate from the DC brushless motor. A theoretical output was .46 kW. After putting the multimeter to the rotating DC motor, a voltage of 10 and amperage of 9 produced 90 Watts of power. This 90 Watts of power is significantly lower than the theoretical .46 kW, due to inefficiencies in the blades and the material not being able to withstand the forces to generate the power. To achieve the power output, a different material than PLA must be chosen.

Aerodynamic values for a flat plate at different angles of attack

Compressor blade 1:
- Angle of attack: 52.51°
- Coefficient of drag: 0.82

Compressor blade 2:
- Angle of attack: 52.51°
- Coefficient of drag: 0.82

Compressor blade 3:
- Angle of attack: 52.51°
- Coefficient of drag: 0.82

Compressor blade 4:
- Angle of attack: 37.62°
- Coefficient of drag: 0.57

Compressor blade 5:
- Angle of attack: 30.74°
- Coefficient of drag: 0.51

Compressor blade 6: 25.79°
- Angle of attack: 25.79°
- Coefficient of drag: 0.42

Upon creation of the Engineering Requirements, the team used drag coefficients to determine the blades efficiency. However, upon reflection the team should have used lift coefficients instead because the lift force from the blades is what determines the rotational speed of the shaft.

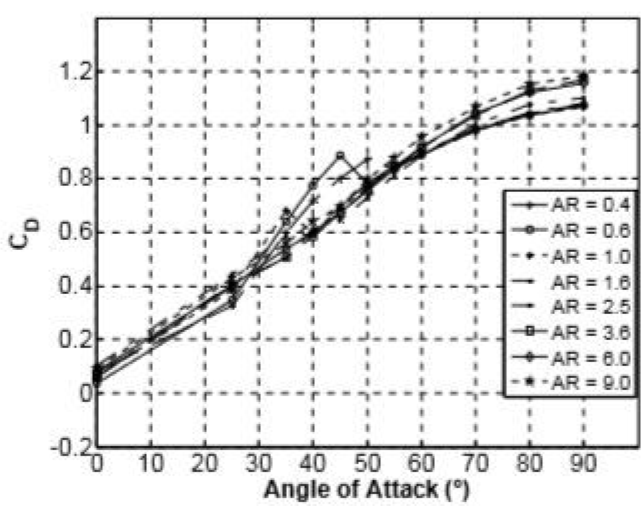


Figure 1: Angle of Attack vs Coefficient of Drag for a Flat Plate

Source: www.mdpi.com/1996-1073/8/4/2438/pdf

Thermal Capacity

During the initial creation of the Engineering Requirements, thermal capacity carried the incorrect units. Upon purchasing Mild Steel for the heat sink, it was researched to find that Mild Steel has a specific heat capacity of 510.7896 J/kg・K.

Table 2: Specific Heat Capacity of Selected Metals

Specific Heat Capacity of Metals Table Chart				
Metal	**Btu/(lb-°F)**	**J/(kg-K)**	**J/(g-°C)**	**Btu/(lb-°C)**
Steel, Mild	0.122	510.7896	0.5107896	0.2196
Steel, Stainless 304	0.120	502.416	0.502416	0.216
Steel, Stainless 430	0.110	460.548	0.460548	0.198

Source:
https://www.engineersedge.com/materials/specific_heat_capacity_of_metals_13259.htm

Volume

Total Volume: 53.73 in^3 = .00088 m^3 << .5 m^3

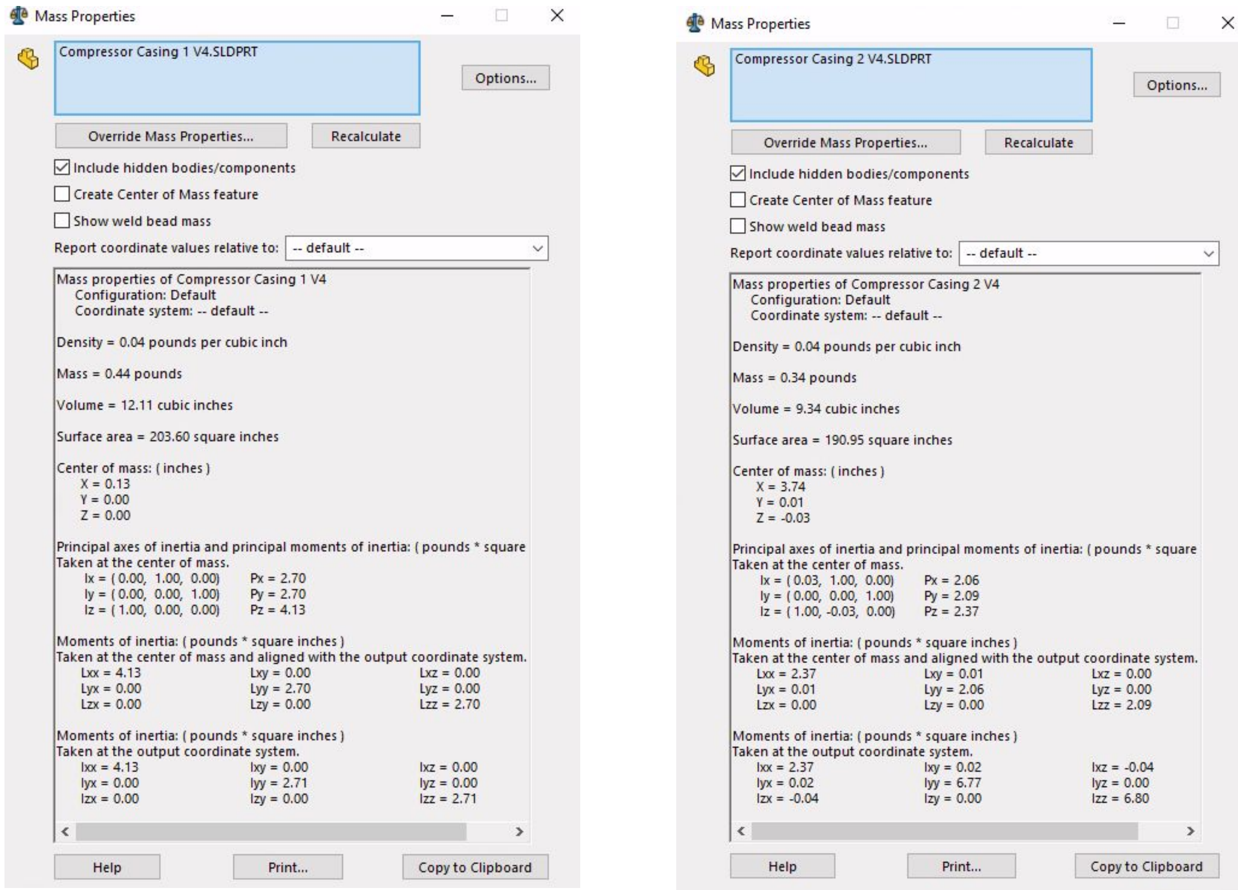
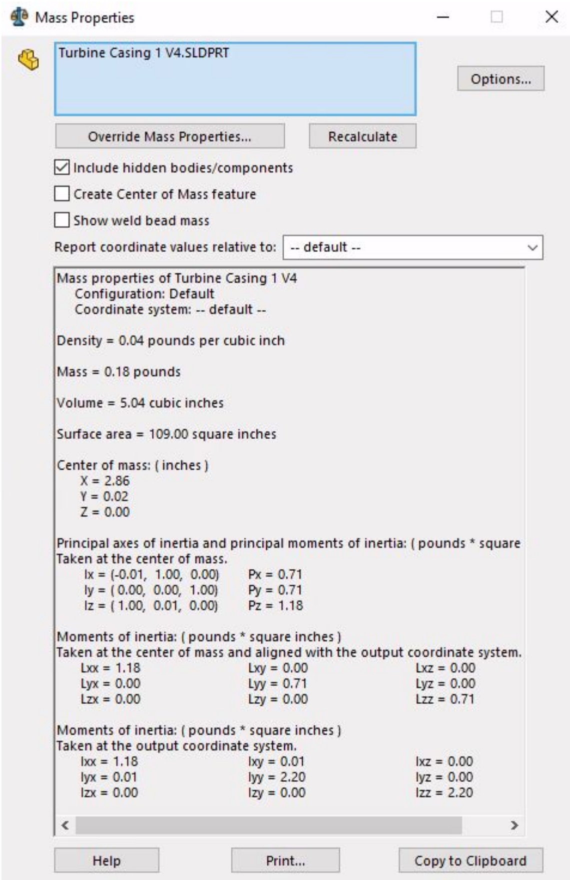


Figure 2: Volume of Casings



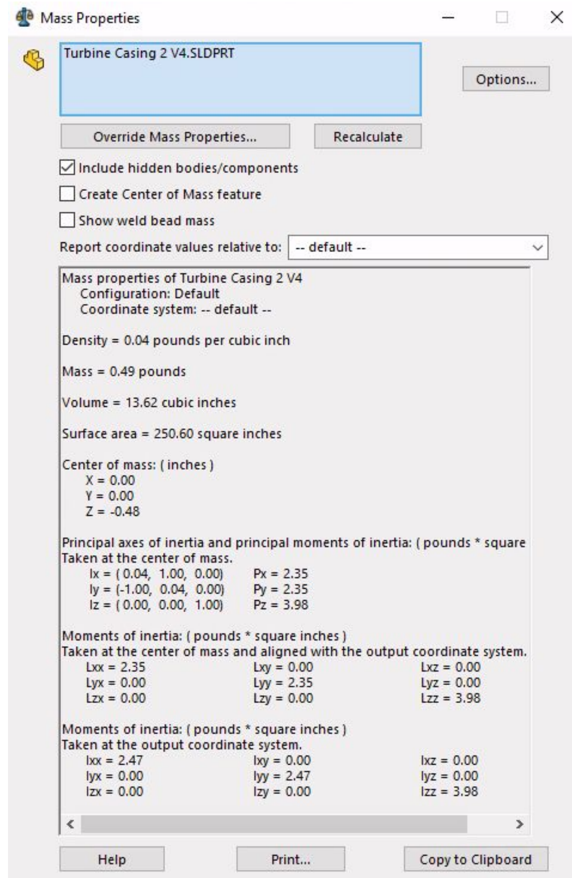


Figure 3: Volume of Casings

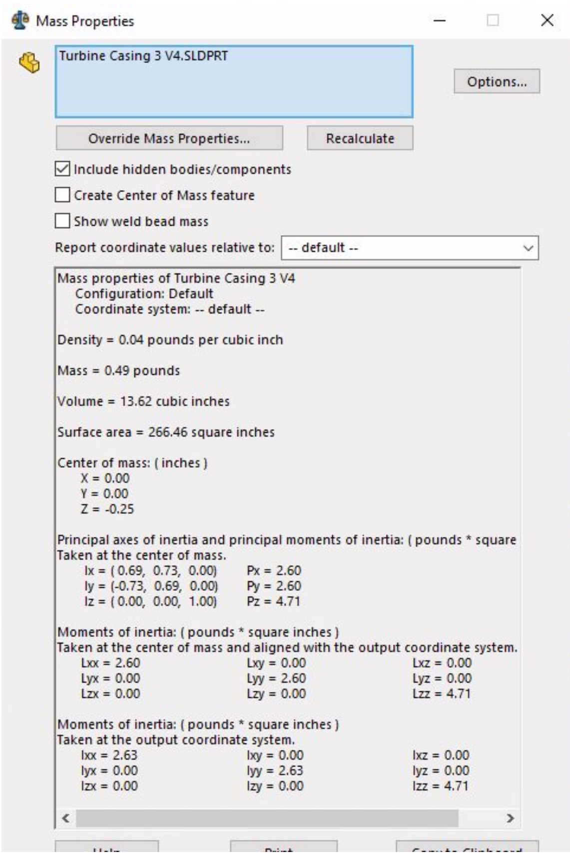


Figure 4: Volume of Casings

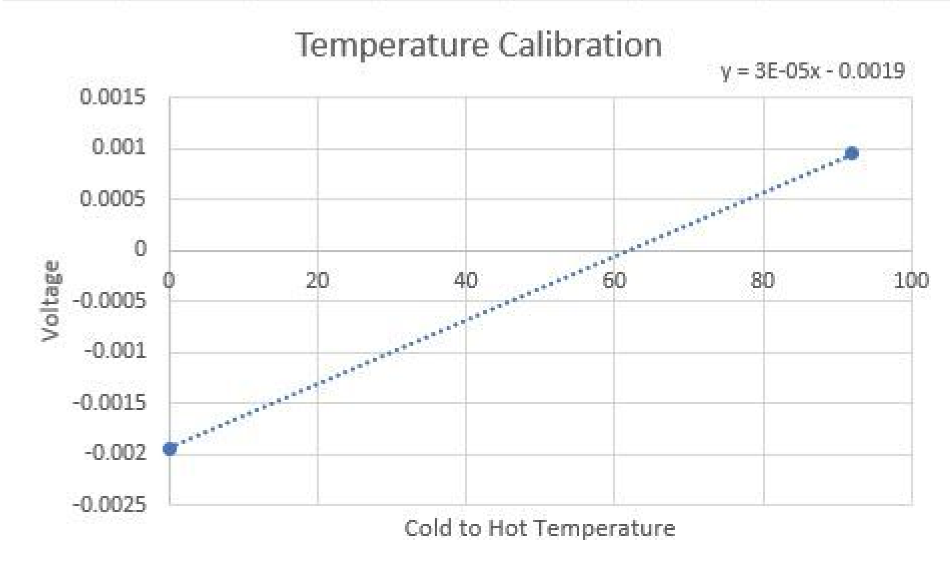
Data Acquisition

Table 3: Temperature Voltages

Time	Voltage_0	Voltage_1	Voltage_2	Voltage_3	Voltage_4	Voltage_!
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95
#########	17.6743	-2455.95	-2455.95	-2455.95	-2455.95	-2455.95

Equation for temperature calibration: $y = 3E\text{-}05x - 0.0019$

Table 4: Temperature Calibration



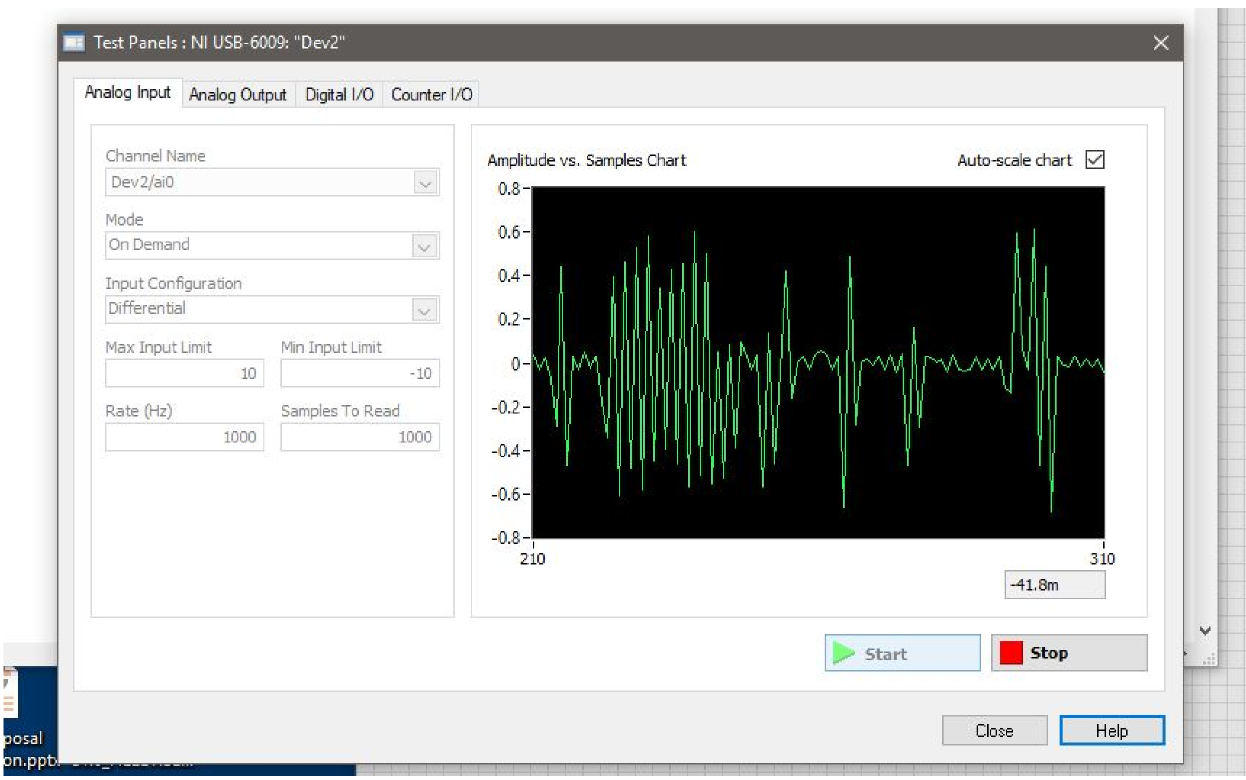


Figure 5: Pressure Transducer Voltages