

Thermodynamics Demonstration Unit 1B Power Generating Turbojet Engine

Operation Manual

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Assembly Manual

EGR 486C-01

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Operating Manual

The following are the procedures, in order, for operating the Brayton cycle demonstration project. This is a working manual of operation for Engineering students in an introductory Thermodynamics class, as well as future prospective students working on an operating Brayton cycle.

Step 1: Ignition Procedures

1.1 Plug in Compressor (17)



Figure 1: Air Compressor (17)

1.2 Plug in Heating Unit (15)



Figure 2: Heating Power Switch (15)

1.3 Plug in Pressure Power (3)



Figure 3: Pressure Power Plug (3)

1.3.1 Plug in Pressure Daq into PC with Labview open (3)



Figure 4: Pressure Data Acquisition Wiring Arrangement

1.4 Assemble Air diffuser to Air compressor



Figure 5: Air Diffuser connection

1.5 Open valve into diffusion entrance (19)

Figure 6: Open Ball Valve (19)

Step 2: Heating Element Operation

Once the air compressor is operating and compressing air, turn the switch to the heat section to on. This will take a few minutes to heat up and transfer heat into the system. Attached to the heat section is a thermal fuse which will keep the temperature of the heat sink to a safe 220 F. 2.1 Turn on heating system (15)



Figure 7: Heating Switch

Safe Run Time: 20 minute, continuous to maintain the integrity of the 3D printed casing.

Step 3: Temperature Acquisition Operation

3.1 Adjust Thermocouple onto Heat Band



Figure 8: Thermocouple Position

Step 4: Pressure Acquisition Operation

4.1 Plug in Pressure position one (3)



Figure 9: Pressure Position One

4.1.1 Acquire Data

4.2 Plug in Pressure position two (3)



Figure 10: Pressure Position Two

4.2.1 Acquire Data

Step 5: Shut Off Procedure

- 5.1 Turn off Heating system (15)
- 5.2 Turn off Pressure System (3)
- 5.3 Allow system to run until no movement
- 5.4 Unplug all power cables

Operational Tests

The following are tests designed to guarantee each component is operating. Troubleshooting components will be handled with the tools specified in each test.

Power Test

Tools: Multimeter Procedure:

Measure motor resistance for quality assurance Measure voltage and current generated from motor

Heat Test

Tools: Thermocouple Multimeter Procedure: Check heating element temperature is below 240° F Check thermal fuse is operational with multimeter Check Aluminum Shroud is safe to touch Pressure Test

Tools: Multimeter Computer Procedure: Measure Voltage generated from pressure transducer Check all wires are connected and communicating to computer

Speed Test

Tools: Stroboscope Procedure: Measure rotational speed of shaft RPM not exceeding 1500 for safe operation

Assembly Manual

This section of the manual includes the assembly methods for the creation of a Power Generating Brayton Cycle.

1. CAD models to create six compressor blades and three turbine blades



Figure 11: Complete Brayton Cycle Staging

2. Casing has been sent out and received, all prints must be cleaned using pliers, a metal file, sandpaper, and a scissors.



Figure 12: Initial Case from 3D print

3. Radial ball bearings are installed in the casing.



Figure 13: Radial ball bearing and placement

4. After parts have been cleaned, they were primed to allow further structural support while maintaining a nice aesthetic



Figure 14: Casing paint priming



Figure 15: Final painting for casing

5. Following painting, assembly onto the shaft immediately occured. Casing is bolted together for support and tolerances.



Figure 16: Bolts into case



Figure 17: Final Turbine result

6. After purchasing a LED strip, connections to the DC brushless motor must be soldered.



Figure 18: LED strip



Figure 19: LED soldering placements



Figure 20: Brushless DC motor electrical inputs



Figure 21: Controller and IR sensor attached to LED strip

7. The collection of the collar heat band, thermal switch, and a galvanized steel tube as a heat sink is the entire heating subsection of the model.



Figure 22: Heat Band on Heat Sink



Figure 23: Thermal Switch



Figure 24: Assembly guide for Heating subsection



Figure 25: Schematic for Heating Assembly

8. After the assembly of the heating subsection, it must be mounted to the shaft.



Figure 26: Heating Subsection mount to shaft

9. A temperature data acquisition was acquired. It will be used to record the temperature states in Labview



Figure 27: Temperature Data Acquisition

10. Acquiring a pressure data acquisition, pressure transducer, wires for DAQ; the full pressure subsystem can be assembled.



Figure 28: Pressure Data Acquisition



Figure 29: Pressure Transducer



Figure 30: Pressure Transducer and Wiring attachment



Figure 31: Wiring for Pressure Data Acquisition



Figure 32: Wiring Diagram for Pressure Transducer



Figure 33: Exploded View Assembly

Bill of Materials

| | Project Name | | Thermodynamic Demonstration Unit 1B | | | | | | |
|-----------------------------------|----------------------|------|---|-----|------------------------------------|-----------|------------------|--|--|
| | Team | | Erich Gemballa, Gavin Geiger, Hamad Almutairi, Abdullah Albdulghafour | | | | | | |
| | | Part | | | | Cost Per | | | |
| | Vendor | # | Part Name | Qty | Description | Unit | Total Cost + Tax | | |
| | 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 | | |
| Structural/ Data Collection | 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.co | | | | | | | | |
| | m | 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 | | |
| | | | | | | | | | |
| | Home Depot | 12 | Heat Sink | 1 | 1.5" x 5" Steel Pipe | \$ 5.99 | \$ 6.93 | | |
| Heat | Тетрсо | 13 | Band Heater | 1 | Collar Heater | \$ 32.30 | \$ 45.09 | | |
| Heat | 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 | | Thermal Tape for Insulation | \$ 4.98 | \$ 4.98 |
|-----------|-----------------|----|------------------------|---|-----------------------------|-----------|-----------|
| | | | | | Total | \$ 61.56 | \$ 87.40 |
| | | | | | | | |
| | CPOOutlets.com | 17 | Air Compressor | 1 | 6 gal 150 PSI Compressor | \$ 89.00 | \$ 96.90 |
| Compresso | Home Depot | 18 | Recoil Hose | 1 | 25 ft Compressor Hose | \$ 14.98 | \$ 16.10 |
| r | Home Depot | 19 | Ball Valve | 1 | Compressor Connector | \$ 8.98 | \$ 9.70 |
| | | | | | Total | \$ 112.96 | \$ 122.70 |
| | | | | | | | |
| | | 20 | Brushless DC Generator | 1 | Power Generation | \$ 20.00 | \$ 20.00 |
| Power | SolidApollo.com | 21 | LED Light Strip | 1 | Light Strip | \$ 14.00 | \$ 15.00 |
| | | | | | Total | \$ 34.00 | \$ 35.00 |
| | | | | | | | |
| | 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 | \$ - |
| 2D Drints | | 28 | Comp Blade 3 | 1 | 3D Print | \$ 10.00 | \$ - |
| 3D FIIILS | | 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 |

Budget

| Matarial | Cost per | Estimated | Manufacturer/Vendo | Dort Number | Cost | Actual cost | Purchas |
|---------------------------------|----------|-----------|---------------------------------|-------------------------------|-------------------|-------------|----------------|
| wateria | Unit | Amount | r | Part Number | Before Tax | w/ tax | ed |
| LED Light Strip | \$14.00 | 1 | SolidApollo.com | SA-LS-RGB-5050-180- 24V-1F | \$14.00 | \$15.00 | Yes |
| Wiring | \$1.00 | 12 | Superbrightleds.com | 24AWG | \$12.00 | | Continu ous |
| Air Compressor w/ 6 Gal Tank | \$89.00 | 1 | <u>CPOoutlets.com</u> | PCBRC2002R | \$89.00 | | Yes |
| 1/4" Bolts | \$0.63 | 13 | Home Depot | | \$8.19 | \$8.19 | Yes |
| DC Generator | \$20.00 | 1 | Pacific Sky Power/Amazon.com | B01KMZQT1Q | \$20.00 | \$0.00 | yes |
| 1.5" Band Heater | \$32.30 | 1 | TEMPCO/grainger.com | 2VXZ6 | \$32.30 | \$45.09 | Yes |
| Compressor Recoil Hose | \$14.98 | 1 | Home Depot | | \$14.98 | \$16.10 | Yes |
| 3/4" Aluminum Shaft | \$47.50 | 1 | McMaster-Carr.com | 1497K31 | \$47.50 | \$41.68 | Yes |
| J Type Thermocouples | \$4.00 | 2 | NAU | 1980-024 | \$8.00 | \$0.00 | Provided |
| Ball Valve | \$8.98 | 1 | PneumaticPlus.com | PSB15-160 | \$8.98 | \$9.70 | Yes |
| Pressure Transducer | \$49.00 | 2 | Tranducers Direct | TDH30BG025003B00 4 | \$98.00 | \$119.98 | Yes |
| Ball Bearings | \$4.95 | 3 | HomCo | | \$14.85 | \$14.85 | yes |
| 3D Prints | \$10.00 | 15 | Rapid Lab/Cline Library | | \$150.00 | \$0.00 | Continu ous |
| 1.5" Diameter Steel Pipe | \$5.99 | 1 | Home Depot | | \$5.99 | \$6.93 | yes |
| Thermal Fuse | \$17.60 | 1 | Grainger.com | 6UDY6 | \$17.60 | 29.57 | Yes |
| Thermal Tape | \$4.98 | 1 | Home Depot | | \$4.98 | \$4.98 | Yes |
| Light Switch | \$0.69 | 1 | Home Depot | | \$0.69 | \$0.69 | Yes |
| Wire Connection Ends | \$2.58 | 1 | Home Depot | | \$2.58 | \$2.58 | Yes |

| Pressure Transducer | | | | | | | |
|----------------------|---------|----|------------|------------------|----------|----------|-----|
| Wire | | 2 | | | \$0.00 | \$0.00 | No |
| Locking Nuts | \$1.18 | 13 | Home Depot | | \$15.34 | \$15.34 | Yes |
| 12 Pack Washers | \$1.18 | 1 | Home Depot | | \$1.18 | \$1.18 | Yes |
| Aluminum Duct Tubing | \$10.48 | 1 | Home Depot | | \$10.48 | \$10.48 | Yes |
| | | | | Estimated Total: | \$576.64 | \$342.34 | |