Turbocharger Jet Turbine Engine

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Group 1
Presentation Overview

• Proposal of Senior Design Project/ Objectives
• Estimated/ Actual Budget
• How Does a Jet Engine Work?
• Parts Required
• Hypothetical Data and Acquisition Methods
• Build Process and Specifications
• Testing Problems/Ramifications
• What We Would Do Differently
Proposed Project

Turbocharger Jet Engine

Objectives

• Design and build a jet turbine engine utilizing a standard automotive turbo
• Have a functioning jet engine that we can use to measure power output, shaft speed, exhaust gas temperature, and thrust.
Homemade Jet Turbine Engine
Were Objectives Met?

• Were we successful at building a working jet engine?
  – Yes

• Were we successful at attaining values?
  – No?
## Budget

- **Estimated:** $300-400
- **Actual:**

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<th>Item</th>
<th>Supplier</th>
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<th>Cost ($)</th>
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<td>Fuel Pump</td>
<td>Jim Ravesi</td>
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<td>Oil Pump</td>
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<td>Fuel Nozzle</td>
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How Does a Jet Engine Work?

• A Jet engine is comprised of:
  o An air compressor – comprised of fan blades that rotate in order to increase the mass flow of air into the engine;
  o A combustion chamber – where fuel is injected and mixed with the compressed air to initiate the combustion process;
  o An exhaust – also comprised of fan blades that use the exhausted air from the combustion chamber to rotate the shaft that rotates the compressor blades to allow for self-propulsion of the jet engine.
Parts Required to Build a Working Jet Engine

• Major components:
  – a Turbocharger
  – Combustion Chamber
    • Combustion Shell
    • Flame tube
  – Ignition System
  – Fuel Pump Motor
Hypothetical Data

• Primary Values:
  – Thrust = 23.2 lbs
  – Shaft Speed = 144,000 RPM
  – Max Mass Flow Rate of Air = 0.558 lbs/s
  – Exhaust Gas Temperature (EGT) = 1195°F

• Values were attained using a program called “JetSpecs – Turbo Analysis”
  – Values were dependent on diameters of inducer, hub, and exhaust outlet.
Sensors for Data Acquisition

- Omron Optical Sensor connected to a Multimeter
  - Record Rotational Shaft Speed
- Thermocouple with a Digital Readout
  - Record EGT
- Analog Pressure Gage
  - Combustion Chamber Pressure
- Liquid-Filled Analog Fuel Pressure Gage
  - Record Fuel Inlet Pressure
Omron Optical Sensor

- To determine EGT, Thrust, Fuel Pressure and Combustion Pressure at given RPM to determine efficiencies.
- Optical Sensor/Photo Interruptor
- Has a refresh rate of 5000 cycles per second
- How would it work:
  - Hooked up to multimeter to measure frequency (Hz), multiply this value by 60 to attain RPM value
Series 40T Digital Thermocouple/RTD Temperature Switch

- J-series Thermocouple
  - Temperature Range: -40 - 1500°F
- Connected to a Love Controller
  - 120 Volt input
Analog Pressure Gage

- Measure Air Pressure of air entering Combustion Chamber
Liquid Filled Analog Pressure Gage

- Measure Fuel Pressure going into Fuel Nozzle
- Help to regulate Fuel Pressure
  - Allow for graph correlations of Shaft Speed and EGT after steady state has been reached
  - Pressure Range: 0-100psi
Build and Specifications

- Turbocharger
- Combustion Chamber
  - Shell and Flame tube
- Ignition System
- Fuel Pump System
Turbocharger

• Type: Garrett Turbo TB28
• Acquired from Rick’s Truck Center
  – Came off of a totaled Nissan UD120 4.6L 4-cyl Turbo Diesel box-truck
• Required disassembly and clean-up before proper function could be achieved.
Sandblasting

Before

After
Corrosion Clean

Before

After
Combustion Chamber

- Combustion Shell
  - Comprised of 304L 0.060” Stainless Steel.
  - Laser cut to specifications, rolled and welded to combustion chamber shape.
  - Dimensions – 6” Dia. X 12” Length
- Flame tube
  - Comprised of 304L 0.125” wall Stainless Steel tubing.
  - Required drilling of holes to allow for air flow into flame tube.
  - Dimensions – 5” Dia. X 11.5” Length
  - Hole Specifications:
    - Primary – 24 x 0.201” Dia.
    - Secondary – 15 x 0.209” Dia.
    - Tertiary – 21 x 0.2813” Dia.
  o Specifications acquired from “Combustor” program
Combustion Shell

Combustion Shell

Flame tube
Ignition System

Forced-Air Heater Spark Plug and Fuel Nozzle

• Comprised of a fuel nozzle and a spark plug inserted in the back of the flame tube.
• Nozzle atomizes diesel fuel for combustion, has a spray rate of 0.8 gph at 80°.
• Spark plug used to ignite fuel.
Ignition System
Fuel Delivery System

- Sundstrand Oil Burning Furnace Pump
  - 100 psi pumping pressure
  - Pump rotates at 3450 RPM
  - 120 Volts
Turbocharger Jet Engine Assembly
Testing Obstacles

- Initial condition of turbocharger
- Ignition and combustion issues due to placement of fuel injector and spark plug
- Modified spark plug did not thread in without bending
- Needed a strong spark and a cap and rotor wasn’t working
- 0.6 gph nozzle didn’t have enough spread. 0.8 gph distributed the fuel better for more efficient combustion
- Fuel lines rupturing/blowing off fittings
- Starting issues due to insufficient RPM’s
- We noticed that the engine was not combusting all delivered fuel
- Fuel pump failure because of internal issues and bleeding
Preliminary Testing

• Testing Stages
  – Stage 1 – Ignition System: Tested how to generate enough voltage for the spark plug to function
  – Stage 2 – Tested how to effectively ignite specified fuels (gasoline and diesel)
  – Stage 3 – Tested placement of fuel nozzle and spark plug: determining sufficient air flow through flame tube orifices
  – Stage 4 – Tested whether Jet Engine was self-sustaining
What Went Wrong

Although it is unknown the exact cause of the failure, the most likely reasons are:

– Excessive RPM’s that were much higher than what the turbo was capable of possibly produced a destructive rotational resonance of the shaft.

– Intense heat rate without letting metal gradually increase in temperature.

– Destructive failure in which the heat caused the metal blades to expand and come in contact with the turbine housing walls.
What We Would Do Differently

• Add another spark plug to burn fuel more symmetrically.
• Have water cooling set up to reduce the heat within the turbine bearings.
• Use a control panel to control all functions and indicators of the engine status.
Future Direction

• Use a larger turbo to attain higher thrust value.
• Have full instrumentation rigged during all testing phases.
• Try various combustion chamber sizes to acquire peak efficiency for the specified turbine.
Was Our Project Successful?

• Our project was a success because we researched, designed, built, and fully understood the methods and process involved in engineering a jet turbine engine.

• Although we were unable to verify our predetermined values, we are confident that, given another opportunity, we would meet all of our goals.

• We have learned the risk and possible malfunctions that can arise during turbine operation.

• From our coursework and education at Wentworth we were able to successfully complete the engineering process involved in designing a prototype from which we could collect data.
Summary

• Successfully researched, designed and built a functioning Jet Turbine Engine utilizing an automotive Turbocharger.
• We were unable to acquire expected data due to the physical failure of the engine.
• Provided a detailed build log of all necessary components and design modifications to illustrate the ability to construct a jet engine.

Our Website
Special Thank to:

• Associated Environmental Systems – BMA
  – Beran Peter
  – David “Rocky” Rockwood
  – Matt Linder
  – Jim Nolan
  – Nathan Simmers
  – Mike Amato

• Rowland Institute at Harvard
  – Don Rogers

• Family
  – Victor Pereira
  – Antonio Cerqueira
Visual Representation