AAE4660
Aeropropulsion Systems
Fall 2009

Laboratory Engine Run-Up #1

11:30pm-1:20pm, October 15, 2009
Aeropropulsion System Test Cell (Kalamazoo Airport)
Report Due: October 21, 2009

MW54 Turboprop Engine

SAFETY FIRST

Objectives

Gain experience in running turboprop engines and examine engine parameters at startup and runs.

General Guidelines

Instrumentation and laboratory layout can be found in the Equipment Guide on the web site at
http://www.mae.wmich.edu/faculty/liou/wp_AE466MW54EquipmentGuide.pdf
Details can be found in Leong et al. (2004) and Liou and Leong (2007) at the course website.

Equipment Description

A partial cutaway of the mini turboprop engine is shown in Figure 1. Other than the slightly modified turbine, the turboprop engine uses a similar gas generator as that in the MW54 turbojet engine. A large free turbine at the downstream of the main gas generator is used to drive the propeller through a reduction gear box. This allows the engine to produce higher torque at lower shaft speeds.

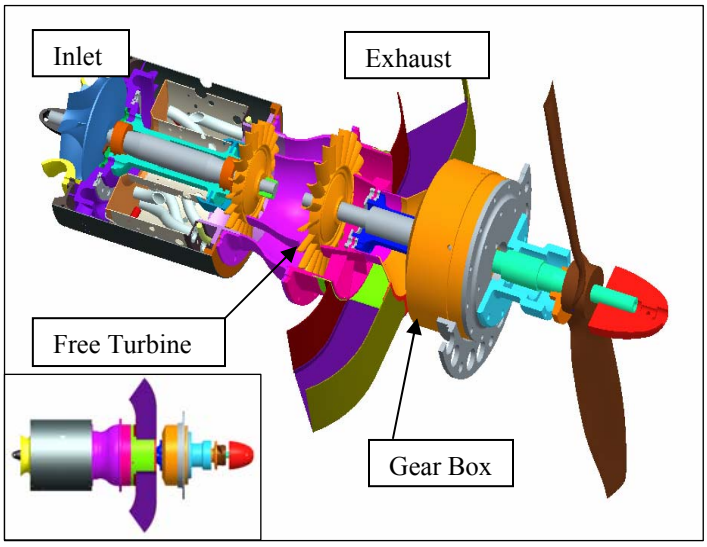

Figure 1. A cutaway view of turboprop engine setup.

Engine Start Up

The auto-start setup includes an ECU, fuel and propane electric valves, and an electric motor with a mechanical clutch system. Once a start sequence is initiated, the ECU supplies power to spin up the electric motor. The mechanical clutch attached on the motor shaft will engage the spinner nut secured on the centrifugal compressor. After the initial spin up to about 5,000 RPM, the glow plug will ignite the propane, increasing the temperature in the combustion chamber. The starter motor will continue to wind the compressor while kerosene fuel is being combusted. Once the core shaft reaches 25,000 RPM, the propane supply will be stopped and at 35,000 RPM, the starter motor will stop and disengage the clutch. Gradual increase in the fuel supply will speed up the engine, until the idle speed of 45,000 RPM is reached.

Measuring Sensors

A custom engine mount incorporates thrust measurement sensor and supply line placements. A slot have been machined out from two pieces of wood and then put together creating a hollow section in the rear support. This allows all supply lines and electronic wirings to be routed through the rear mounting leg into the lower section of the test bench and to be cleared from the high speed air behind the propeller.

A voltage output strain gage type load cell was installed on the bottom plate of the engine mount to measure thrust. Figure 2 illustrates the placement of the load cell and the measurement technique being used. The thrust line, F1, above the pivot pins of the upper plate where the engine is mounted will create a moment that applies force, F2, directly onto the load cell. Using simple moment summation calculation, force F2 is obtained by dividing the product of force F1 and distance L1 by distance L2. Calibrating forces to linear voltage output from the load cell, thrust can be determined. To compensate for any forces lost to friction, calibrations were done by transferring dead weights forces parallel to the propeller thrust line through a pulley system. We have also used the setup to test the rigidity of the wood stand and up to 50 lbs of weight have been loaded.

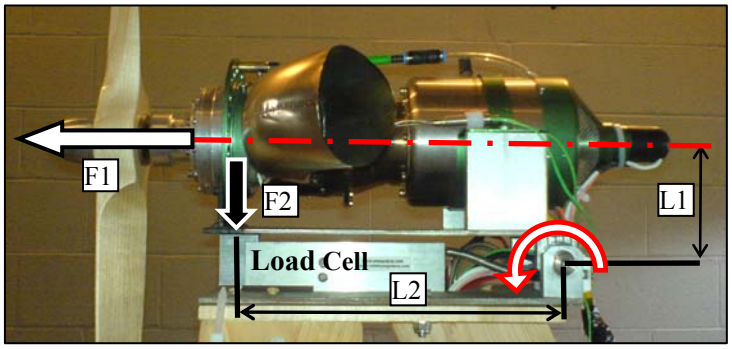

Figure 2. Turboprop thrust measurement and mounts.

A Hall Effect core shaft speed sensor comes with the kit and was installed. A thermocouple was also installed to measure the temperature of the exhaust gas downstream of the main turbine. In addition, a second thermocouple was used to measure the exhaust air temperature downstream of the second free turbine. A case pressure port was installed with a digital pressure gage to provide a digital readout from the computer. Also, a light sensitive propeller speed indicator was attached onto one of the "tripod" legs. Since a fuel flow meter was installed on the engine fuel supply line, the fuel supply can be switched between the turbojet and the turboprop engines. As illustrated in Figures 3, the turboprop engine is secured on a tripod like wood mount on the test bench next to the turbojet engine.

Data

Engine throttle level, RPMs, thrust, EGT, case pressure, and fuel flow rate. Engine throttle level will be indicated by RPMs. Thrust load cell and fuel flow rate meter data will not be available.

Report

Must contains

1. Title page
2. Abstract
3. Raw data and figures
4. Discussion of the results

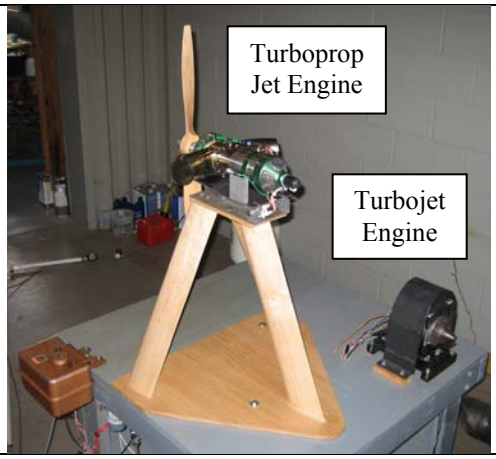

Figure 3. Turbine engines test setup.

References

C.H. Leong, J. Jacob and W.W. Liou, ``*Development of a Turbojet Engine Lab for Propulsion Education*," 40th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Ft. Lauderdale, FL, July 11-14, 2004. AIAA 2004-4085.

W.W. Liou and C.H. Leong, "*Gas Turbine Engine Testing Education at Western Michigan University*," 45th AIAA Aerospace Science Meeting and Exhibit, Reno, Nevada, 8-11 January 2007. AIAA 2007-703.