

# Engine-Scale Combustor Rig Designed, Fabricated, and Tested for Combustion Instability Control Research

Low-emission combustor designs are prone to combustor instabilities. Because active control of these instabilities may allow future combustors to meet both stringent emissions and performance requirements, an experimental combustor rig was developed for investigating methods of actively suppressing combustion instabilities. The experimental rig has features similar to a real engine combustor and exhibits instabilities representative of those in aircraft gas turbine engines. Experimental testing in the spring of 1999 demonstrated that the rig can be tuned to closely represent an instability observed in engine tests. Future plans are to develop and demonstrate combustion instability control using this experimental combustor rig.

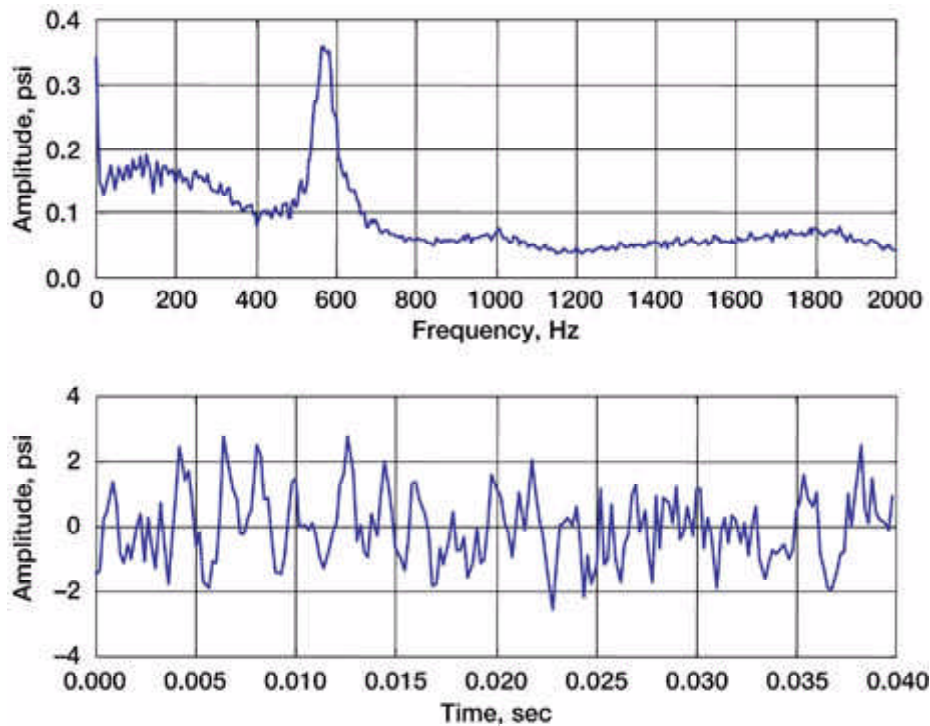
The NASA Glenn Research Center at Lewis Field is leading the Combustion Instability Control program to investigate methods for actively suppressing combustion instabilities. Under this program, a single-nozzle, liquid-fueled research combustor rig was designed, fabricated, and tested (see the photo). The rig has many of the complexities of a real engine combustor, including an actual fuel nozzle and swirler, dilution cooling, and an effusion-cooled liner.



*Experimental combustor for stability and active control experiments.*

Prior to designing the experimental rig, a survey of aircraft engine combustion instability experience identified an instability observed in a prototype engine as a suitable candidate for replication. The frequency of the instability was 525 Hz, with an amplitude of approximately 1.5-psi peak-to-peak at a burner pressure of 200 psia. The single-nozzle experimental combustor rig was designed to preserve subcomponent lengths, cross-sectional area distribution, flow distribution, pressure-drop distribution, temperature distribution, and other factors previously found to be determinants of burner acoustic frequencies, mode shapes, gain, and damping.

Analytical models were used to predict the acoustic resonances of both the engine combustor and proposed experiment. The analysis confirmed that the test rig configuration and engine configuration had similar longitudinal acoustic characteristics, increasing the likelihood that the engine instability would be replicated in the rig. Parametric analytical studies were performed to understand the influence of geometry and condition variations and to establish a combustion test plan. Cold-flow experiments verified that the design values of area and flow distributions were obtained. Combustion test results established the existence of a longitudinal combustion instability in the 500-Hz range with a measured amplitude approximating that observed in the engine (see the graphs). Modifications to the rig configuration during testing also showed the potential for injector independence.



*Experimental power spectral density and partial time trace of combustor internal pressure show 500-Hz thermoacoustic instability.*

The research combustor rig was developed in partnership with Pratt & Whitney of West Palm Beach, Florida, and United Technologies Research Center of East Hartford, Connecticut. Experimental testing of the combustor rig took place at United Technologies Research Center.

**Find out more about this research**

<http://www.grc.nasa.gov/WWW/cdtb/projects/combustor/>.

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