

⚙️ Ejector-Enhanced, Pulsed, Pressure-Gain Combustor

Specific fuel consumption of a gas turbine engine could be reduced by a few percent.

John H. Glenn Research Center, Cleveland, Ohio

An experimental combination of an off-the-shelf valved pulsejet combustor and an aerodynamically optimized ejector has shown promise as a prototype of improved combustors for gas turbine engines. Despite their name, the “constant pressure” combustors heretofore used in gas turbine engines exhibit typical pressure losses ranging from 4 to 8 percent of the total pressures delivered by upstream compressors. In contrast, the present ejector-enhanced pulsejet combustor exhibits a pressure rise of about 3.5 percent at overall enthalpy and temperature ratios compatible with those of modern turbomachines. The modest pressure rise translates to a comparable increase in overall engine efficiency and, consequently, a comparable decrease in specific fuel consumption. The ejector-enhanced pulsejet combustor may also offer potential for reducing the emission of harmful exhaust compounds by making it practical to employ a low-loss rich-burn/quench/lean-burn sequence.

Like all prior concepts for pressure-gain combustion, the present concept involves an approximation of constant-volume combustion, which is inherently unsteady (in this case, more specifically, cyclic). The consequent

unsteadiness in combustor exit flow is generally regarded as detrimental to the performance of downstream turbomachinery. Among other adverse effects, this unsteadiness tends to detract from the thermodynamic benefits of pressure gain. Therefore, it is desirable in any intermittent combustion process to minimize unsteadiness in the exhaust path.

One of the easiest ways of approximating constant-volume combustion is to use a process similar to that used in commercially available pulsejets. Unfortunately, the pulsed combustion effluent is far too hot for any turbine and must, therefore, be mixed with some cooler bypass flow. The mixing process introduces losses that substantially degrade overall engine performance.

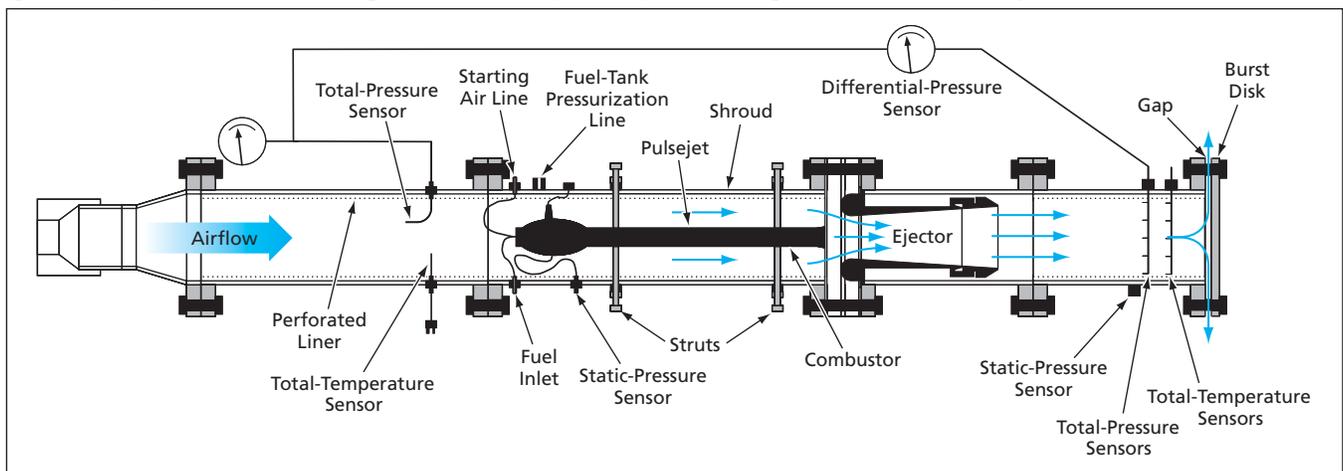
The present concept of the ejector-enhanced pulsejet combustor utilizes the demonstrated ability of properly designed, unsteady-flow ejectors (augmentors) to efficiently entrain, mix, and smooth secondary flows. The aerodynamically optimized ejector is placed aft of the pulsejet combustor. The pulsejet combustor and the ejector are encased in a shroud (see figure). The ejector is essentially an axisymmetric, tapered duct

with an aerodynamic inlet. The ejector entrains the cool secondary flow to produce an exhaust flow in a temperature range that can be tolerated by turbomachinery. Acting in combination with the shroud, the ejector also reduces spatial and temporal nonuniformities in the flow, thereby mitigating the detrimental effects of the pulsed combustion process. Finally, the relatively high momentum-transfer efficiency of the ejector ensures that taken as a whole, the ejector-enhanced pulsejet combustor yields a modest, time-averaged pressure rise.

In tests, the root-mean-square value of exit pressure fluctuations was found to be about 4.5 percent of the mean total pressure. This value is near the limit above which pressure fluctuations are considered to adversely affect the performance of downstream turbomachinery.

This work was done by Daniel E. Paxson of Glenn Research Center and Kevin T. Dougherty of QSS Group, Inc. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18096-1.



The Ejector-Enhanced Pulsejet Combustor mounted in a test rig is depicted here in cross section, approximately to scale.