NASA TECH BRIEF

Lewis Research Center

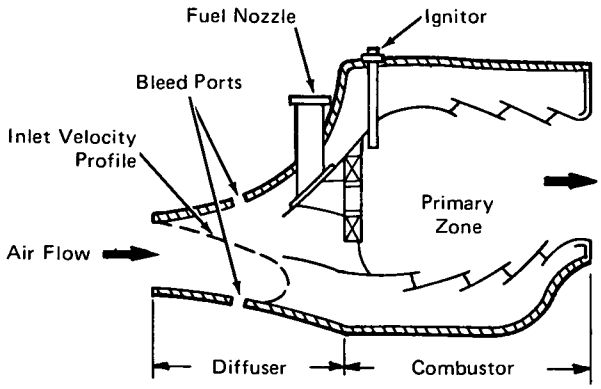
Airflow Distribution Control for Improved Turbine Engine Performance

The problem:

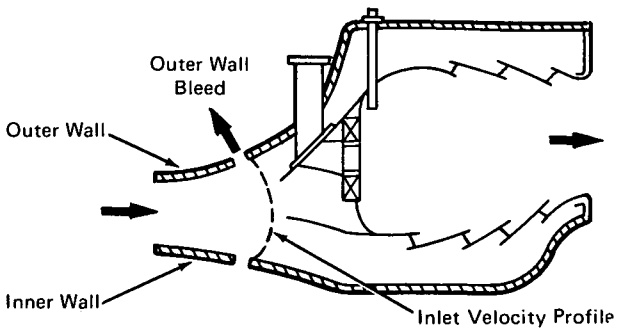
To provide a practical method by which the distribution of airflow entering aircraft gas turbine engine combustors can be varied to improve engine performance at idle, take off, cruise, and altitude relight. The advantages of a gas turbine engine equipped with combustor airflow distribution control would be threefold: (1) a significant reduction in diffuser length, and hence weight, since the short diffuser flow separation problem could be controlled; (2) annoying combustor exhaust emissions during engine idle could be drastically reduced by reducing airflow to the primary combustion zone; (3) combustor altitude relight capability could be greatly improved by creating a low velocity recirculation zone around the fuel nozzles and ignitors.

The solution:

Velocity profile control experiments conducted with a short annular diffuser equipped with wall bleed (suction) capability indicate that the diffuser bleed technique could be effectively used in controlling gas turbine combustor airflow distribution. Preliminary data obtained from a full scale gas turbine combustor using a bleed-type diffuser also demonstrate this combustor airflow control capability, even though the combustor had not been designed to operate with a bleed-type diffuser.



A. IDLE OR ALTITUDE RELIGHT OPERATION



B. CRUISE OR TAKEOFF OPERATION

How it's done:

A short annular combustor designed to operate with the diffuser bleed concept, referred to as a "controlled separation combustor," is shown schematically in the figures. The diffuser geometry is asymmetric with a rapidly diverging outer wall and a gradually diverging inner wall. Bleed ports (or slots) permit a small fraction of the diffuser inlet airflow to be ducted through the diffuser walls at certain operating conditions.

The use of bleed flow would depend on the desired combustor inlet velocity distribution at a given operating condition. When no wall bleed is used, the asymmetric diffuser geometry causes the flow to adhere to the inner wall but to separate from the outer wall. The resulting combustor inlet velocity distribution would allow most of the flow to bypass the primary zone of the combustor as required for engine idle and altitude relight conditions. Hence, the desired velocity distribution could be obtained at these conditions without applying diffuser bleed as indicated in Figure A.

Figure B shows the proposed bleed combustor during

(continued overleaf)

takeoff or cruise operation. Since now there is sufficient static pressure differential between the diffuser and turbine inlet stations, a certain percentage of the airflow may be bled off through the bleed ports in the outer wall of the diffuser and used for turbine cooling. The effect of bleed on diffuser flow would be to cause attachment to the outer wall, thereby flattening the velocity profile. A small amount of bleed on the inner wall could also be applied to trim the profile if necessary. The uniform airflow distribution would provide sufficient cooling air for inner and outer combustor liners and also improve the pattern factor at the turbine inlet. Also, the high diffuser effectiveness obtainable with a uniform outlet profile would improve engine cycle efficiency by reducing combustor pressure loss.

Notes:

1. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)
   Reference:
   NASA TN-D-6435 (N71-30817), Preliminary Investigation of Diffuser Wall Bleed to Control Combustor Inlet Airflow Distribution
2. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B72-10178

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to:

Patent Counsel
Mail Stop 500-311
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(LEW-11593)