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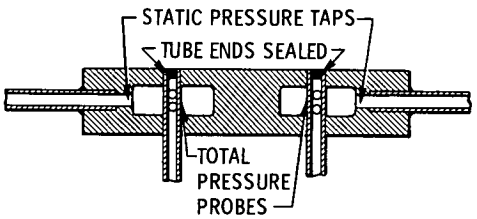
NASA TECH BRIEF

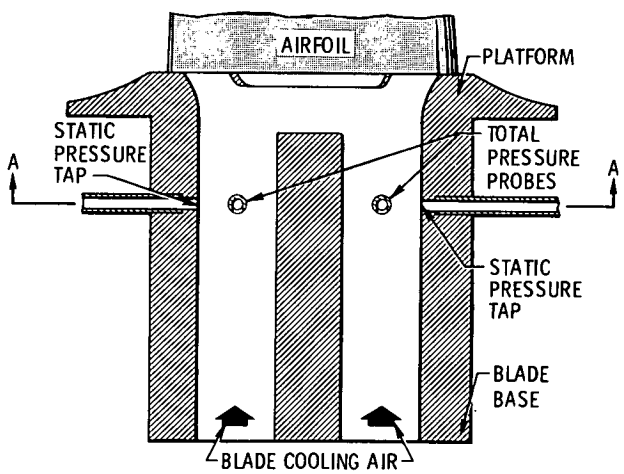
Lewis Research Center

A Method for Measuring Cooling Air Flow in Base Coolant Passages of Rotating Turbine Blades

A flow measuring method has been developed that accurately determines the actual coolant mass flow rate in the cooling passages of rotating turbine blades. Total and static pressures are measured in the blade base coolant passages. Mass flow rates are calculated from these measurements of pressure, a measured temperature and a known area.



SECTION A-A



BLADE INSTRUMENTATION (NOT TO SCALE).

Static pressure is measured with small diameter (0.051 cm (0.020 in)) taps that are mounted normal to the inside of the blade base air passage (see figure). Total pressure is sensed with two small diameter (0.051 cm (0.020in)) holes spaced 0.127 cm (0.050 in) apart in 0.0813 cm (0.032 in) tubing in each air passage. These tubes are centered in the air flow passages with the axes of the holes placed parallel to the direction of flow.

The sensed pressures are ducted to variable reluctance differential pressure transducers mounted near the shaft centerline. These rotating transducers convert the pneumatic pressures into electrical signals that are transferred by a slip ring assembly to stationary recording equipment. The pressure differences indicated by the transducers are corrected for temperature, rotational effects on the air columns contained by the ducting, and, when relevant, rotational effects on the transducers. Mass flow rates are calculated from these corrected pressure differences. Shaft speeds of 0-9000 rpm and air mass flow rates of 0.0035 to 0.039 kilogram per second (0.0077 to 0.085 lbm/sec) have been measured with this system.

Conventional methods for determining cooling air mass flow rates through rotating turbine blades use instrumentation located in the stationary portion of the coolant supply system. Coolant system leakages which may occur downstream of the measuring station are accounted for through use of calibrations and calculations. While it is usually possible to calibrate and/or calculate the coolant system leakage at cold stationary conditions, it is not possible to apply such procedures with a high degree of confidence when the turbine component is hot and rotating. Therefore, to obtain an accurate determination of the coolant flow rate being delivered to a rotating cooled turbine blade, it is desirable to make measurements at a point which is downstream of all potential points of coolant system leakage.

Individual rotating flow measurements of blade mass flow rates using this new method agreed with corresponding stationary flow measurements using a calibrated reference orifice within 10 percent at shaft speeds from 0 to 9000 rpm.

(continued overleaf)

Notes:

1. Further information is available in the following report:

   NASA TN-D-7697 (N74-25950), Flow Measurement in Base Cooling Air Passages of A Rotating Turbine Blade

   Copies may be obtained at cost from:

   Aerospace Research Applications Center
   Indiana University
   400 East Seventh Street
   Bloomington, Indiana 47401
   Telephone: 812-337-7833
   Reference: B75-10017

2. Specific technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B75-10017

Patent Status:

NASA has decided not to apply for a patent.

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