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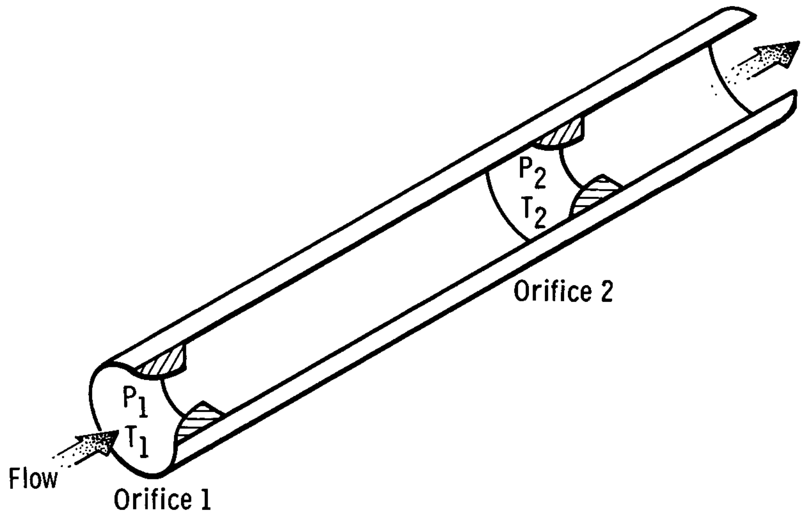
Total-Pressure Measurement in Pulsating Flows



The Problem:

The steady-state indications of total pressure measuring tubes placed in pulsating flows, such as found in turbomachinery systems, are often assumed to be the true time average of the pulsating total pressure. In general, the equations for the flow into and out of the tube are not linear with respect to the applied pressure, and therefore, the indicated pressure may not be the time average of the applied pressure pulsation. A method was needed to determine whether nonlinear averaging effects were serious in unknown pulsating flows.

The Solution:

A pneumatic-type probe, conventionally used for the measurement of total temperature, was used as a comparison instrument with total pressure tubes to determine true average pressure and, thus, to determine if the nonlinear averaging effects were significant.

How It's Done:

The probe which consists of two sonic flow orifices in series is shown schematically in the figure. Conventionally, the total temperature T_1 in front of the probe is calculated by equating the mass flow rate through the two orifices and measuring total pressures P_1 and P_2 and the temperature T_2. If the two temperatures are equal, or measurable, the probe can be used to obtain the total pressure in front of the first orifice and in this way the time average of pulsating stream total pressure. For frequencies in the kHz range (the lower frequency limit depends on the volume between the two orifices), the flow through the second orifice is essentially steady. The probe is calibrated in a gas stream of known total pressure and temperature to obtain the value

$$\frac{C_2 A_2}{C_1 A_1}$$

where C is orifice coefficient and A is orifice area, and with this factor total pressure values can be determined. In use, the pressure P_2 in front of the second orifice is measured. This pressure multiplied by the value

$$\frac{C_2 A_2}{C_1 A_1}$$

(continued overleaf)

gives the total pressure P_1. If there is a temperature variation between the two orifices, P_1 is determined by the formula

$$P_1 = P_2 \left(\frac{C_2 A_2}{C_1 A_1}\right) \sqrt{\frac{T_1}{T_2}}$$

Notes:

1. Since the pneumatic probe is more complicated to use than a total-pressure tube, it is used only as a comparison instrument to determine the extent of averaging effects.
2. Further information is available in the following report:
   NASA TM-X-68128 (N72-32316), Total-Pressure Averaging in Pulsating Flows
   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: B73-10252
3. Specific technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B73-10252

Patent Status:

NASA has decided not to apply for a patent.

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