AIRFLOW MEASUREMENT LAB

PURPOSE: The main purpose of this lab is to measure the volumetric flow rate of air down a short length of pipe in 3 different ways. These are: (1) a venturi meter (2) an orifice plate (3) a conical inlet. Another purpose is to estimate flow using flow speed measurements.

PROCEDURE: Set the air flow rate down the pipe using the control valve. For each valve setting, measure: (1) the pressure drop at the venturi using the digital meter and the manometer (2) the pressure drop across the orifice plate using the digital meter (3) the pressure drop at the conical inlet using the digital meter. For one valve setting, measure: (1) the flow speed at points across the inlet cone (2) the pitot static tube pressure at points across the pipe.

REPORT: Using the pressure data, calculate the flow rate predicted by each device. Estimate the flow rate using the inlet cone speed data and the pitot static tube pressure data. Identify reasons for any disagreement between the various predictions.

FLOW FROM PRESSURE DROP MEASUREMENTS

When a flow in a pipe passes through a constriction, it speeds up. Theory shows that when it speeds up, pressure drops. This drop can be used to get an estimate of flow. The flow speed S_D at the constriction is

$$S_D = \sqrt{[2(P_U-P_D)/\rho]}/\sqrt{[1-(A_D/A_U)^2]}$$

$$S_D = \sqrt{[2(P_U-P_D)/\rho]}/\sqrt{[1-(D_D/D_U)^4]}$$

where U indicates upstream conditions and D indicates conditions at the constriction. The flow rate is

$$Q = K\ S_D\ A_D \qquad A = \pi D^2/4$$

For the venturi, the loss factor K is equal to 0.98 while for the orifice it is equal to 0.59 and for the conical inlet it is 0.95. The diameter of the main pipe is 5.5 inches. The diameter of the venturi is 3.5 inches. The diameter of the orifice is 4.25 inches. The diameter of the inlet pipe is 5.5 inches. The diameter of the cone attached to it is 7 inches.

FLOW FROM SPEED MEASUREMENTS

Flow rate can be obtained by integrating speed over flow area. For a circular pipe one gets:

$$Q = \Sigma S_k A_k \qquad A_k = \pi D_k \Delta D$$

where the pipe area is broken into annular strips. For the inlet cone, the S values are obtained directly using the digital meter. They do not vary much across the face of the inlet so one can approximate the flow rate by an average speed times the total flow area.

For a pitot static tube, theory shows that speed is

$$S = \sqrt{[2\Delta P/\rho]}$$

In the lab, we measure ΔP using the digital meter. The S values do not vary much across the pipe so one can approximate flow rate by an average speed times area.

PRESSURE DATA FOR VENTURI

RUN	DIGITAL METER	MANOMETER

PRESSURE DATA FOR ORIFICE AND INLET

RUN	ORIFICE	INLET

SPEED DATA FOR CONICAL INLET

LOCATION	DIGITAL METER

PITOT STATIC TUBE PRESSURE DATA

LOCATION	DIGITAL METER