Title: **AIRFLOW MEASUREMENTS**
Ref Number: **1**
Location: **NATIONAL COLLEGE LABORATORY**
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Team Size: **~4**
Environment: **INDOORS**

OBJECTIVE

To compliment theory discussed in lectures
To gain familiarity with various instruments
To assess the relative merits of various devices

APPARATUS

Anemometers:
1. Orifice Plate
2. Conical Inlet
3. Wilson Grid
4. Pitit Static Tube
5. Hot Wire
6. Vane

THEORY

There are many instruments available for measuring air volume flow rate in ducts. The choice of instrument depends upon the application, access; speed of reading; frequency of reading; accuracy; need for calibration, degree of skill required; need for mathematical processing or charts; portability; reliability; and of course cost.

Most devices for measuring airflow depend on pressure drop; change in heat loss rate or the turbine. To facilitate the comparison, a rig has been built complete with all three types of instruments and a manometer to allow rapid readings to be taken.

Based on a 200mm diameter circular duct

Ambient air density $\rho = 1.2 * \left(\frac{b}{1013}\right) * \left(\frac{293}{273+t}\right) kgm^{-3}$

where b is the actual atmospheric pressure in mbar.
t is the actual air temperature in ^{O}C.

1. Orifice Plate- 120mm

Note: the equation shown here is a simplification of the current British Standard method in which the value C_d must be determined. For most cases the equation below is sufficiently accurate.

Volume flow rate, $Q = C_d * A_o \sqrt{\left(\frac{2\Delta P}{\rho * \{1 - m\}^2} \right)} in \cdots m^3 / s$

where ΔP is measured pressure drop in Pa
C_d is the coefficient of discharge=0.61
A_o is the area of the orifice in m^2
m is the ration of A_o/A_d, where A_d is the duct area in m^2

2. Conical Inlet- 160mm

Note: the equation shown here is a simplification of the current British Standard method in which the value C_d must be determined. For most cases the equation below is sufficiently accurate.

Volume flow rate, $Q = C_d * A_d \sqrt{\left(\frac{2\Delta P}{\rho} \right)} in \cdots m^3 / s$

where ΔP is measured pressure drop in Pa
C_d is the coefficient of discharge=0.96
A_d is the duct area in m^2

3. Wilson Grid

The Wilson grid is similar in principle to a number of pitot-static tubes permanently fixed in the duct at specific intervals over the cross section. This allows the average velocity to be determined from a single reading. However, a correction must be made to the measured pressure difference.

Volume flow rate, $Q = A_d \sqrt{\left(\frac{2\Delta P}{\rho C} \right)} in \cdots m^3 / s$

where C is the correction (enhancement) factor=2.7

4. Pitot-static Tube

Volume flow rate, $Q = A_d * v, in \cdots m^3 / s$

where A_d is the duct area in m^2
v is the average air velocity calculated from the velocity at each point

velocity at each point, $v = \sqrt{\left(\frac{2\Delta P}{\rho} \right)} in \cdots m^3 / s$

where ΔP is the velocity pressured measure in Pa

5. Hot Wire Anemometer

Volume flow rate, $Q = A_d * v, in \cdots m^3 / s$

where A_d is the duct area in m^2
v is the average air velocity calculated from the velocity at each point

velocity at each point, $v = reading * C * \sqrt{\left(\frac{1.2}{\rho}\right)} in \cdots m^3 / s$

where C is a correction factor obtained from the calibration chart

6. Vane Anemometer

Volume flow rate, $Q = C * A_d * v, in \cdots m^3 / s$

where C is the correction factor from the calibration chart
A_d is the duct area in m^2
v is the average air velocity reading from the anemometer in m/s

PROCEDURE

Record barometric pressure and room air temperature

Check the digital manometer battery condition. Select the 0-1999 Pa range and slow speed. Set to zero (making sure both bleed ports of the manifold are open to the atmosphere.)

Set the speed controller to minimum and start the fan.

Stage 1: Increase the speed up to the 40% region. Commence measurements. It is important that between all readings that the manifold to the manometer is allowed to return to atmospheric pressure by opening both bleed ports.

Stage 2: Repeat the measurements with the speed controller set to about 60%.

Stage 3: Reduce the speed of the fan until the pressure reading on the ORIFICE PLATE is equal to the first pressure reading obtained. **Repeat Stage 1**.

RESULTS

In order to allow a meaningful comparison of **accuracy** the measurements should be taken for a number of airflow rates using variable speed fan drives. The **ORIFICE PLATE** should be selected as the standard against which others are compared. To examine **repeatability**, one airflow rate should be repeated and the new results compared with those previously obtained.