Experiment No. 06:

Measurement of Gas Flow Through Pipelines

I Introduction

Experimental Objective

1. To calibrate an orifice flow meter for a given upstream pressure.
2. To calibrate a rotameter.

Procedure

The schematic of apparatus is shown in FIG 1. The orifice plate (d=5mm diameter) is fitted in a pipeline of inner diameter (D=13.7mm). The outflow from the orifice meter is connected to a rotameter, and then to a drum-type gas flow meter. The pressure upstream of the orifice plate is adjusted using a needle valve.

For a set upstream pressure (can be varied using AIRMATIC pressure regulater), adjust the valve downstream to obtain various flow rates. For each flow, note down the differential pressure indicated by the digital manometer.

II Formulas and Other Useful Data

From Bernoulli's equation, the differential pressure can be expressed as,

$$\triangle p = p_1 - p_2 = \frac{1}{2}\rho((V_2)^2 - (V_1)^2) \tag{1}$$

and Continuity equation,

$$A_1 V_1 = A_2 V_2 \tag{2}$$

where $A_1 and A_2$ are the cross sectional areas of pipe and the orifice plate. Combining (1)and (2), we end up with the following relation,

$$V_1 = \sqrt{\frac{\triangle p}{[\frac{1}{2}\rho((\frac{D}{d})^4 - 1)]}} \tag{3}$$

The theoretical or the ideal volume flow rate can be estimated from the velocity and the corresponding cross-sectional area. The actual volume flow rate is known from the drum type flow meter. Density ρ is calculated from ideal gas law for the ambient air($P_{amb} = 1.0132 Bar$). It is necessary to evaluate the discharge co-efficient C_D. It is defined as follows,

$$C_D = \frac{Q_{actual}}{Q_{theoritical}} \tag{4}$$

III Working Principle of Flow meter

This type of flow meter works under the principle of positive displacement. There is a cylinder with four separate compartments immersed in a pool of liquid (water or light oil). See figure below. The

cylinder is mounted on a spindle that is free to rotate. When the air enters a compartment it exerts a pressure on the free surface of water. This would eventual cause the spindle to rotate because the spindle needs less force than to deform and move the the free surface. The spindle rotation is transferred to a rotating indicator through a gear mechanism. When the compartment moves up, eventually the air from the compartment leaves out through the exit port.

A Precautions

Usually water is filled to certain level indicated by a red mark in the water level indicator. The calibration of the flow meter is done by adjusting the water level. One must assure that the water is filled to the level indicated before performing any measurements. There is a restriction on the inlet pressure. So do not exceed 0.5 BAR gauge pressure. This may damage the drum. Do not close the air exit at any cause. Never exceed the flow specified by the manufacturer.

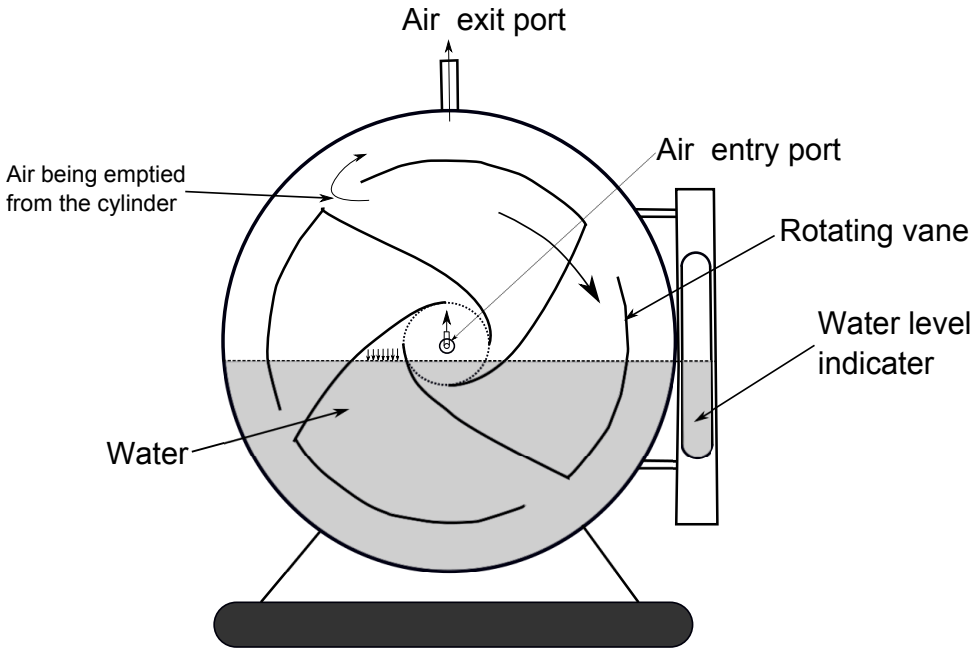

FIG. 1: A interior schematic of flow meter

IV Outcome Expected

1. Actual and ideal volume flow rates, calibration chart, and coefficient of discharge of the orifice flow meter.
2. Rotameter calibration in the form of a look-up table or chart.

Observation Tabulation

S.no.	Rotameter reading	Orifice Δp(Pa)	Mass flow meter	
			Rotation	time(s)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

Make Sure that your report contains the following

1. Objective
2. Apparatus required
3. Working Principle
4. Procedure
5. One sample calculation
6. Result Tabulation
7. Graphs enumerated in section (IV)
8. Observations and Conclusions