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Analysis Of Velocity Profile By Using Pitot Tube

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Abstract - *This document is about checking velocity of water flowing through pipe and analyzing its velocity profile. This is to be done by using pitot tube which is pressure measuring device, Differential U- tube manometer, Differential pressure sensor. The main objective behind this project is to analyze theoretical velocity and actual velocity in given flow and comparing them*

Keywords- *Pitot tube, Differential pressure sensor, Velocity profile, Differential U- tube manometer.*

I. INTRODUCTION

The main emphasis of our project is to analyze the velocity profile of fluid (water) flowing through pipe, to measure velocity at different points along the diameter of pipe and to differentiate between actual and theoretical velocities along the pipe diameter. This analysis is to be done by using pitot tube. Pitot tube is pressure measuring device which measures stagnation pressure at various points.

The Pitot tube was invented by the French engineer Henri Pitot in the early 18th century and was modified to its modern form in the mid-19th century by French scientist Henry Darcy, air and gas flow velocities in industrial applications. The pitot tube is used to measure the local flow velocity at a given point in the flow stream and not the average flow velocity in the pipe or conduit. The mechanism works by converting the kinetic energy of the flow into potential energy. It is used to determine the difference between static, dynamic, and total pressure of a fluid at the same time. Initially, it was used to measure the velocity of a river.

Differential pressure sensor and Differential U- tube manometer to calibrate pressure difference, after calibration we have plotted graph of velocity profile.

II. COMPONENTS

1. Pitot tube:

Pitot tube is pressure measuring device. It is simple hollow tube having bend in right angle. This pitot tube measures stagnation pressure. Another pressure point is static pressure point which is measured by simple vertical hollow tube (piezometric tube).

Fig.(a) : Simple pitot tube and Piezometric tube

2. Tanks:

Inlet tank and outlet tank of 0.2104 m^3 (0.45m×0.55m×0.85m) volume is use to store water. We use this water for experiment and to get constant pressure head. This size of tank is convenient for experiment.

3. Pipes:

PVC pipe of diameter 84 mm and length 3m is used for velocity profile analysis. Another pipe of diameter 27mm (1 inch) pipe to lift water from outlet tank to inlet tank through pump

4. Pressure sensing devices:

4.1. Differential U- tube manometer:

U tube manometer is U- shaped structure filled with mercury, it measures slight difference in pressure. It has two inlet ports to sense two different pressures coming from pitot tube and piezometric tube.

Fig (b) : Differential U- tube manometer

4.2. Differential pressure sensor:

Differential pressure sensor senses the pressures from pitot tube and piezometric tube digitally. This pressure sensor directly measures and show values digitally.

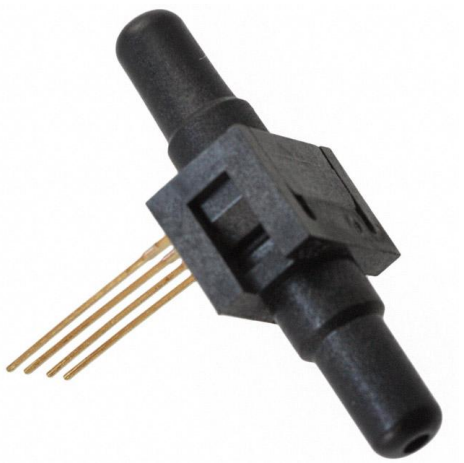

Fig. (c) : Differential pressure sensor

5. Arduino Uno:

Arduino Uno is a microcontroller board based on ATmega 328. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz crystal oscillator. Program is uploaded by USB connection. Power supply is provided by an AC-DC adapter 12V and 1Amp. It receive the signal from pressure sensor displays it on screen.

Fig.(d) : Arduino UNO

III. CALCULATIONS

For analysis, we kept the head constant at 0.12m (12 cm)

We measured the velocity by theoretical as well as practical methods

1. Theoretical calculations:

$$H = \frac{V^2}{2g} + \left(\frac{1}{2}\right)\frac{V^2}{2g} + \frac{4fLV^2}{2gd}$$

Where,

H = Distance between water level and center of pipe (Head) = 0.12m

V =Velocity of water flowing through pipe.

g = Acceleration due to gravity = 9.81 m/s

f = Coefficient of friction.

$$f = \frac{16}{R_e}$$

R_e = Reynolds number.

$$R_e = \frac{\rho v d}{\mu}$$

Where,

d = Internal diameter of pipe = 0.085 mm

ρ= Density of water = 1000 kg/m^3

μ = Dynamic viscosity = 8.9 × 10^{-4} Ns/m^2

L = Length of pipe = 3m

We get the value of velocity of water,

V = 1.11 m/s

2. Practical calculations:

2.1. By using Differential U- tube Manometer:

Formula for calculating difference of liquid column in U- tube Manometer,

$$h = X\left\{\left(\frac{S_{Hg}}{S_w}\right) - 1\right\}$$

Where,

h = Difference of liquid column in U- tube Manometer

S_{Hg} = Specific gravity for mercury = 13.6

S_w = Specific gravity for water = 1

X = Difference in height of manometer in m.

Formula for calculating velocity,

$$V = \sqrt{2gh}$$

Where,

V = Velocity of water flowing through pipe at given point.

g = Acceleration due to gravitational = 9.81 m^2/s

Observed velocity at five different diametrical points,

Sr. No.	Diametrical distance in m	Pressure difference (h) in m	Velocity (v) in m/s
1	0	0.00	0
2	0.021	0.01	1.57
3	0.042	0.015	1.92
4	0.063	0.01	1.57
5	0.084	0.0025	0.8

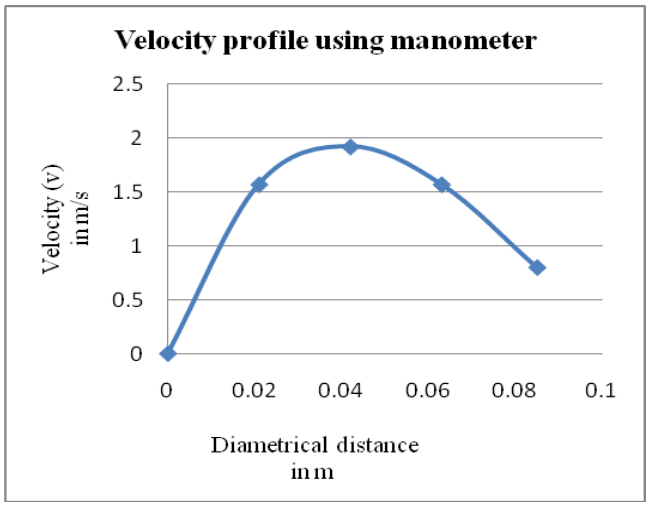

Fig. (e) : Velocity profile using manometer

2.1. By using Differential pressure sensor:

Formula for calculating velocity by using pressure sensor,

$$V = \sqrt{\frac{2(\Delta P)}{\rho}}$$

Where,

V = Velocity of water flowing through pipe at given point.

ρ = Density of water = 1000 kg/m^3

ΔP = Pressure difference between pitot tube and piezometric tube.

Observed velocity at five different diametrical points,

Sr. No.	Diametrical distance in m	Pressure difference (ΔP)	Velocity (V) in m/s
1	0	80	0.4
2	0.021	1328	1.63
3	0.042	1620	1.80
4	0.063	1155	1.52
5	0.084	720	1.20

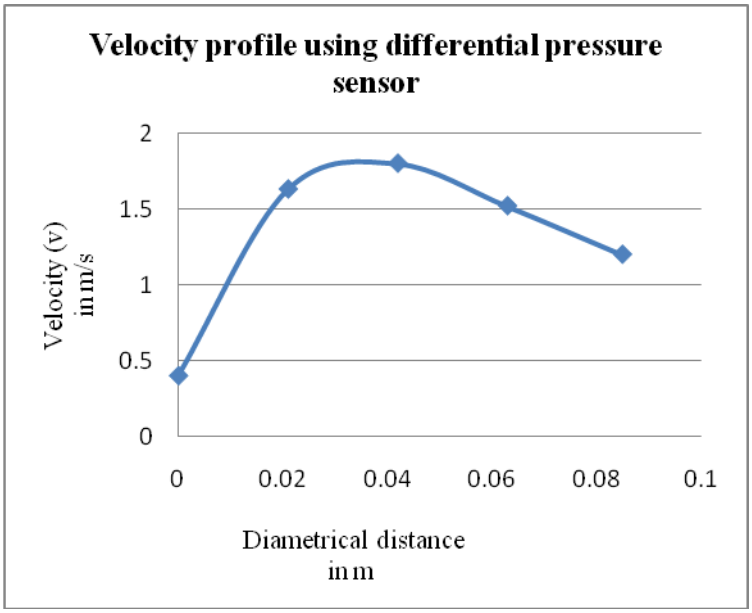

Fig. (f) : Velocity profile using manometer

IV. CONCLUSION

Theoretical velocity and actual velocity of water in pipe is near about same which are as follows,

1. Theoretical calculations:
   V = 1.11 m/s
2. Practical calculations:

2.1. By using Differential U- tube Manometer:
   V = 1.92 m/s

2.2. By using Differential pressure sensor:
   V = 1.80 m/s

V. REFERENCES

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