Experiment- 5

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Bernouli Equation

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1. Aim:

1. Verify if Bernoulli equation is satisfied.
2. Verify does estimated P(pressure) and observed P(pressure) are same.

2. Apparatus:

C15-10 - Computer Controlled Subsonic Wind Tunnel

2.1 Description:

- The C15-10 is a computer controlled compact wind tunnel designed for benchtop operation.
- Air is drawn through the working section by a variable speed fan at the discharge end of the tunnel providing up to 34m/s air velocity.
- A honeycomb flow straightener is incorporated at the inlet, and a 9:4:1 contraction ratio which ensures an uniform airflow through the working section.
- The wind tunnel is supplied as standard with an in-depth software interface providing control of the fan speed and additionally display important parameters such as static pressure and air velocity.
- The optional models are mounted through a circular hatch using quick release clamps (120mm diameter). The placement of the optional models has been designed to minimise the disturbance to air flow and reduction in flow rate, whilst incorporating an angular scale allowing the model to be manually rotated to known angles.

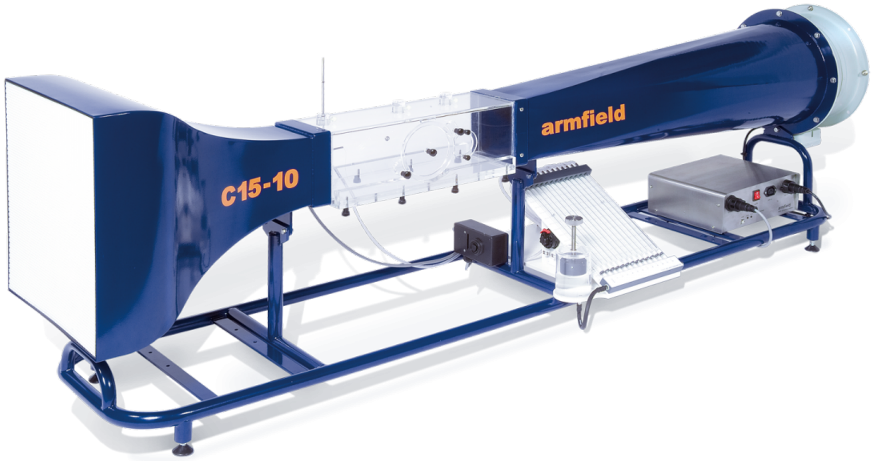

Figure 1: C15-10 - Computer Controlled Subsonic Wind Tunnel

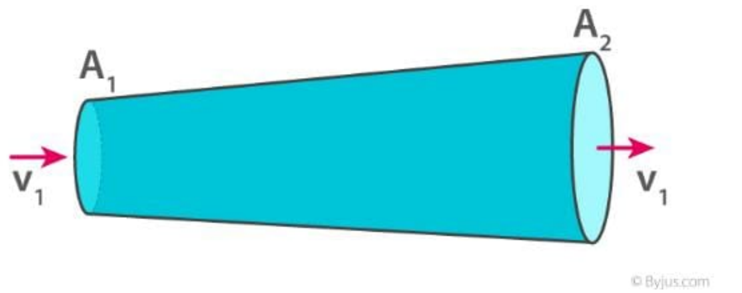

Figure 2: Equation of Continuity

3. Theory:

Bernouli's principle states that **The total mechanical energy of the moving fluid comprising the gravitational potential energy of elevation, the energy associated with the fluid pressure and the kinetic energy of the fluid motion, remains constant.** Bernoulli's principle can be derived from the principle of conservation of energy.

3.1 Assumptions:

- Incompressible Flow - Negligible changes in density of the flow.
- Inviscid Flow - There should not present any viscous effect.
- Steady Flow - States of the flow should not vary with time.
- Flow should be irrotational and along same streamline.

3.2 Principle of Continuity:

If the fluid is in streamline flow and is in-compressible then we can say that mass of fluid passing through different cross sections are equal. Using the principle of continuity:
$A_1V_1 = A_2V_2$

4. Formula:

Bernoulli's equation formula is a relation between pressure, kinetic energy, and gravitational potential energy of a fluid in a container. The formula for Bernoulli's principle is given as follows:

$$P + \frac{\rho v^2}{2} + \rho gh = constant.$$

P = Static Pressure

$\rho = Density of the fluid$

v = speed of the flow

g = acceleration due to gravity

h = elevation

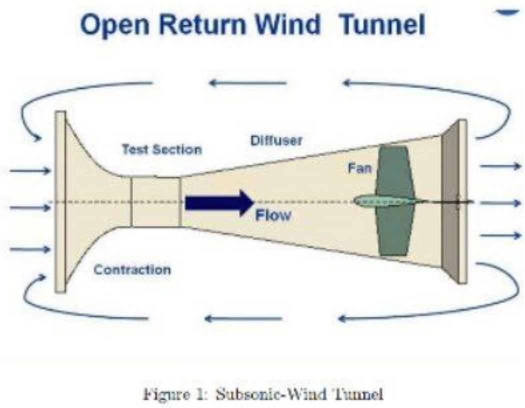

Figure 3: Equation of Continuity

5. Procedure:

- Attach the apparatus with power supply but keep the supply off.
- Do the safety checks like there is no loose connection.
- Set the fan speed on the desktop such that inlet speed remains in range of 25 m/s,after safety checkings,
- Write down the readings in raw data table.
- Increase the fan speed by same amount everytime and repeat the process.

6. Result:

Port No.	Area of cross section(in mm^2
1	22,350
2	19,860
3	17,370
4	15,000
5	15,000
6	15,000
7	16,395
8	17,902
9	19,410
10	20,910
11	22,410

Table 1: Theoretical data for corresponding mass and pressure

For v=12m/s

Port No.	$P_(exp)(in mm of water)$	$P_(theo)(in mm of water)$	percentage error
1	9.7	9.324	4.03
2	11	11.809	6.85
3	13	15.437	15.79
4	17.2	20.701	16.91
5	19.1	20.701	7.73
6	19	20.701	8.22
7	17.5	17.328	0.99
8	15.8	14.533	8.72
9	14.7	12.363	18.90
10	13.3	10.653	24.84
11	11.9	9.275	28.30

For v=16m/s

Port No.	$P_exp(in mm of water)$	$P_theo(in mm of water)$	percentage error
1	16.5	16.577	0.46
2	18.8	20.994	10.45
3	20.8	27.444	24.21
4	29.5	36.802	19.84
5	33.3	36.802	9.51
6	33.3	36.802	9.51
7	30.4	30.805	1.31
8	27.3	25.836	5.67
9	24.9	21.979	13.29
10	22.6	18.938	19.34
11	20.5	16.488	24.33

For v=20m/s

Port No.	$P_exp(in mm of water)$	$P_theo(in mm of water)$	percentage error
1	26.7	25.901	3.08
2	30.7	32.803	6.41
3	34.8	42.8821	18.85
4	51.6	57.503	10.27
5	59.3	57.503	3.13
6	58.6	57.503	1.91
7	53.8	48.133	11.77
8	47.7	40.368	18.16
9	43.4	34.341	26.38
10	39.4	29.591	33.15
11	35.8	25.762	38.96

7. Graph:

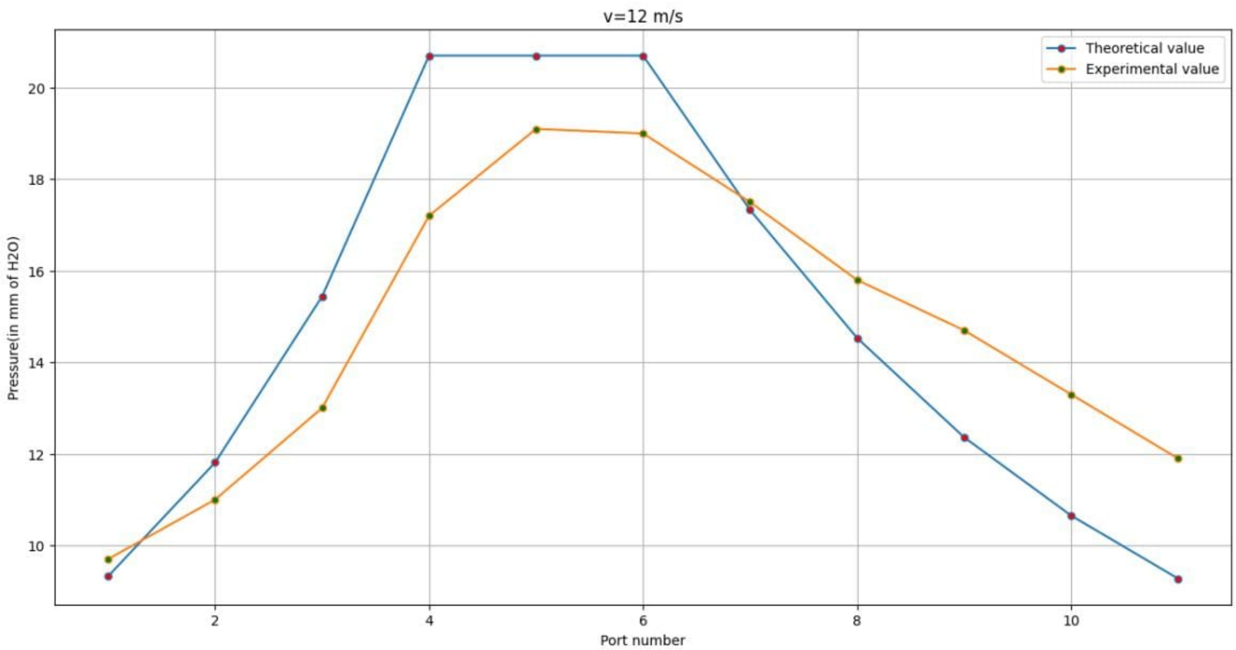

Figure 4: Experimental pressure vs theoretical pressure while loading

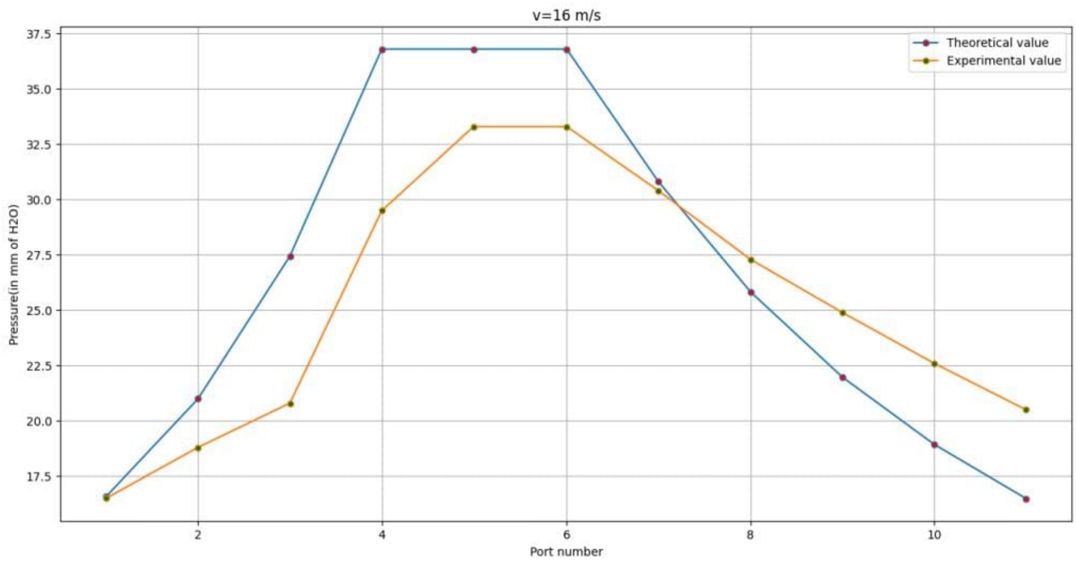

Figure 5: Experimental pressure vs theoretical pressure while unloading

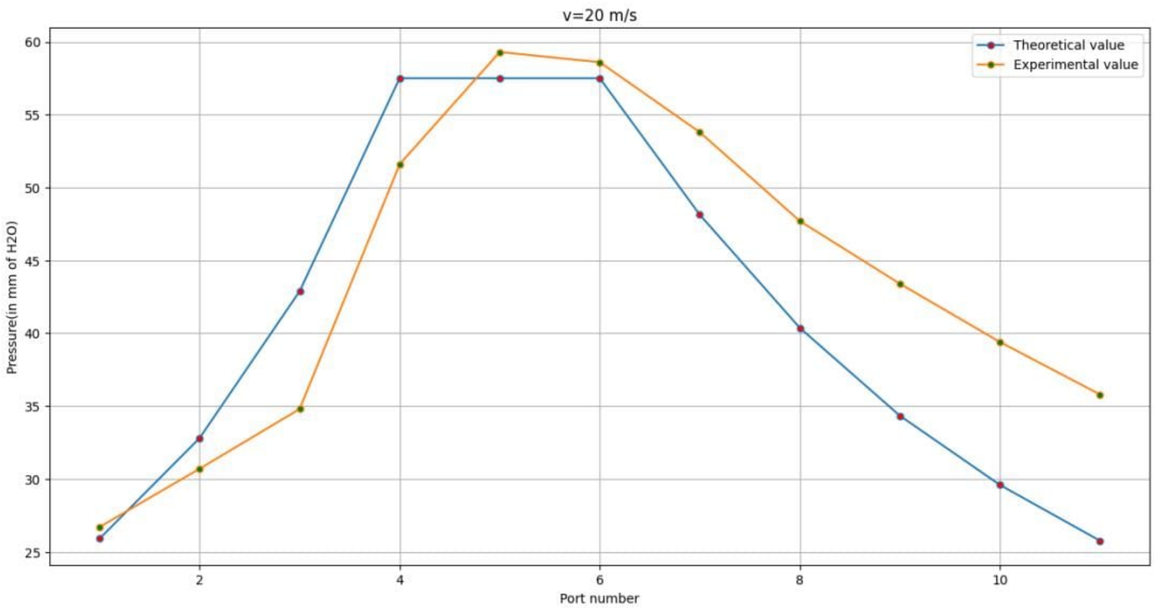

Figure 6: Average experimental pressure vs theoretical

8. Inference:

The experimental value is little different from theoretical value due to different sources of errors and making some assumptions while performing the experiment.

9. Sources of error:

- Instrumental errors.
- Human errors
- Irregularity in environental condition like temperature,humidity,air speed etc..
- Due to assumptions for Bernoulis theorem.

10. Conclusion:

Bernouli equation holds for steady and incompressible flow. There is approximately 10 percent error in each port of our experiment.So we can conclude that,the flow-stream follow Bernouli's Equation.