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I.Objective and Requirements

Familiarize with the principles and construction of the wind tunnel.

Know how to use the static pressure data to determine tunnel air velocity.

Understand the working principles of the Pitot tube and hot wire anemometer.

Measure the basic characteristic parameters of the wind tunnel.

Requirements

(1) Ensure that the required model and/or measuring instrument has been securely installed in the working section.

(2) Any adjustable or removable features must be fastened or clamped to prevent movement.

(3) Ensure that all appropriate hatches, covers etc have been secured.

(4) Ensure that nothing is obstructing the inlet or the outlet of the wind tunnel.

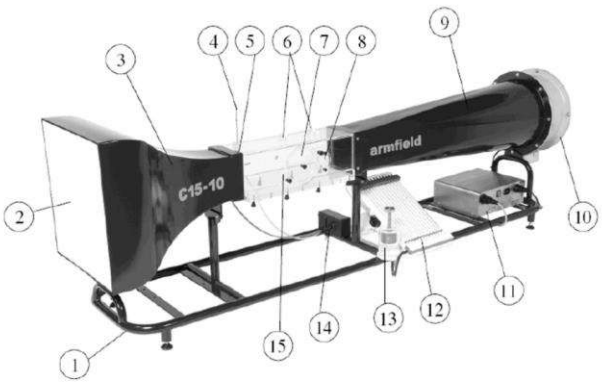


Figure 2 Equipment Diagrams
1. Frame 2. Honeycomb type flow straightener 3. Contraction cone 4. Electronic pressure sensor 6. three tappings 7. circular opening 8. smaller hatch 9. Diffuser 10. Fan 11. Armfield IFD7 Electrical Console 12. manometer 15. working section

(5) Ensure that the IFD7 Electrical Console has been connected to the USB port on the control PC.

(6) Switch on the RCD at the rear of the IFD7 Electrical Console.

(7) Switch on the mains power switch at the front of the IFD7 Electrical Console.

(8) Always keep the safety rules in mind.

II.Principles

1．Wind velocity from the tunnel static pressure

Velocity in the working section is related to the static pressure inside the working section by the relationship

$$v = \sqrt{\frac{2(P_0 - P)}{\rho_a}}$$

Where v is wind velocity, P_0 is atmospheric pressure, P is tunnel static pressure, and ρ_a is the density of air.

In the case of this experiment, pressures are given as the height of water (water head) by the relationship:

$$P = -\rho_w g h$$

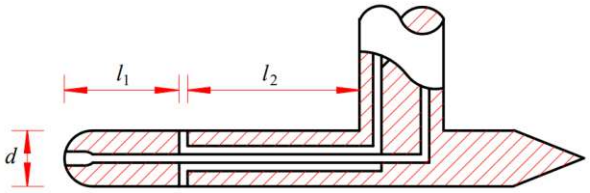
Where ρ_w is the density of water and h is static head.

Combing the two equations, we obtain:

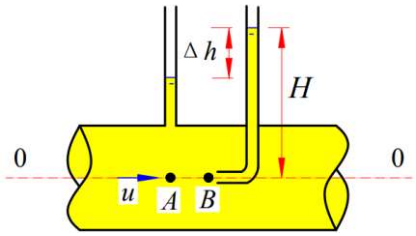
$$v = \sqrt{\frac{2\rho_w g h}{\rho_a}}$$

2．Pitot tube

Pitot tubes were invented by Henri Pitot in 1732 to measure the flowing velocity of fluids, and the following figure is a schematic drawing of a pitot tube.



The following figure shows the measuring principle of Pitot tube.



Application of Bernoulli's equation to the Pitot tube provides the relationship:

$$V = \sqrt{\frac{2\Delta P}{\rho_a g}} = \sqrt{\frac{-2\rho_w g(h_2 - h_1)}{\rho_a}}$$

Where V is the measuring point velocity, ΔP is the difference in pressure between total and static tappings, h_2 is total head, and h_1 is static head.

This equation assumes that the flow is incompressible at the low velocities experienced within the wind tunnel (negligible correction if v < 100 m/s).

3 . Hot Wire Anemometer

Hot wire anemometers are one of the types of thermal anemometers used to measure the direction and velocity of the fluid stream by measuring the heat loss of the wire, which is kept in a fluid stream.

The working principle is based on the change in temperature of the wire, which is from high to low. It determines the relationship between the resistance of the wire and the wind speed. It is used to measure the speed of the wind by placing the sensor in the wind stream that is to be measured. The instantaneous velocity of the fluid can be determined from the voltage measurements.

The anemometer should be calibrated before use. In this experiment, we calibrate the hot wire by simultaneously measuring its experimental data with the Pitot tube. When the relationship between the wind speed and the hot wire voltage is obtained, the calibration relationship can be obtained by polynomial fitting the data.

4. Turbulence

The flow in the wind tunnel is generally turbulent, and we need to collect data for a period of time for analysis.

$$\bar{V} = \frac{\sum_{i=1}^{N} v_i}{N}$$

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N} (v_i - \bar{V})^2}{N-1}}$$

$$I = \frac{\sigma}{\bar{V}}$$

$\bar{V}$ is mean velocity, σ is pulsation velocity (root mean square velocity), and I is turbulence intensity.

III.Data Analysis and Results

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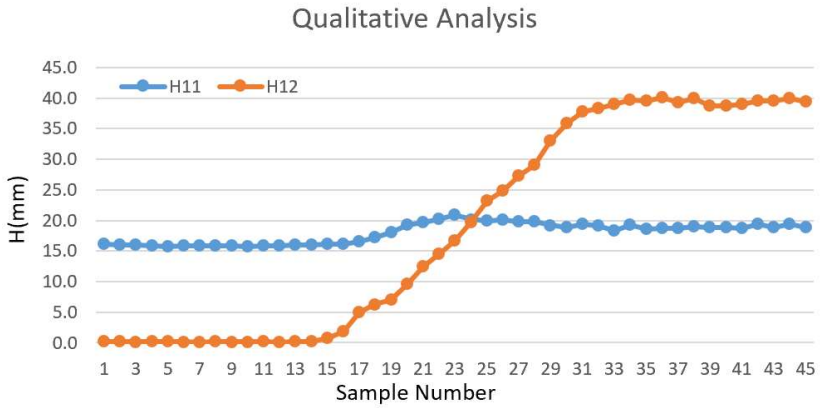
Part1 Qualitative Analysis

Allowing time for the fan to stabilize at 50%, the following figure can be obtained after turning the Pitot tube from 0-90 degrees.



Description

decrease

The figure demonstrates that the measured total pressure increases rapidly while the measured static pressure has a little increment and almost maintains steady.

Reason

The static pressure head(H11) is measured when the wall is parallel to the flow, but after rotation, the contact surface between the flow and the wall changes into a curved surface, so the data measured by static pressure has a little change compared with before.

According to flow around cylinder, the pressure coefficient is -1 after seperation. There are four static tappings, one with total pressure and 3 after seperation, the measured pressure is the average of the four tapping pressure.

When the probe is rotated, the incoming flow is not directly facing the tube inlet, the measured pressure will decrease and the water surface height will decrease, so the corresponding measured head(H12) will increase as shown in the figure.

this pressure is much smaller than the static pressure due to flow separation

Part2 Quantitative Analysis

1. Calculate the Tunnel and Tip velocity based on the pressure measurement in the wind tunnel for each wind speed. do not need to list the data

Tunnel and Tip velocity for 15% wind speed should use 1 Hz or with much longer time

Time [s]	Head H11 [mm]	Head H12 [mm]	Ambient Temperature t [°C]	Water Density [kg/m^3]	Air Density [kg/m^3]	g [m/s^2]	Tunnel Velocity [m/s]	Tip Velocity [m/s]
0.00	1.69	0.00	23.83	1.00	1.19	9.79	5.28	5.28
10.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
20.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
30.00	1.65	0.00	23.83	1.00	1.19	9.79	5.21	5.21
40.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
50.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
60.00	1.69	0.00	23.83	1.00	1.19	9.79	5.28	5.28
70.00	1.69	0.00	23.83	1.00	1.19	9.79	5.28	5.28
80.00	1.69	0.00	23.83	1.00	1.19	9.79	5.28	5.28
90.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
100.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
110.00	1.69	0.00	23.83	1.00	1.19	9.79	5.28	5.28
120.00	1.69	0.00	23.83	1.00	1.19	9.79	5.28	5.28
130.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
140.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
150.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
160.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
170.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
180.00	1.69	0.00	23.83	1.00	1.19	9.79	5.28	5.28
190.00	1.78	0.00	23.83	1.00	1.19	9.79	5.41	5.41
200.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
210.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
220.00	1.78	0.00	23.83	1.00	1.19	9.79	5.41	5.41
230.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
240.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
250.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
260.00	1.69	0.00	23.83	1.00	1.19	9.79	5.28	5.28
270.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
280.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
290.00	1.74	0.00	23.83	1.00	1.19	9.79	5.35	5.35
300.00	1.78	0.00	23.89	1.00	1.19	9.79	5.41	5.41

Tunnel and Tip velocity for 20% wind speed

Time [s]	Head H11 [mm]	Head H12 [mm]	Ambient Temperature t [°C]	Water Density [kg/m^3]	Air Density [kg/m^3]	g [m/s^2]	Tunnel Velocity [m/s]	Tip Velocity [m/s]
0.00	2.82	0.00	23.95	1.00	1.19	9.79	6.82	6.82
10.00	2.86	0.00	23.95	1.00	1.19	9.79	6.87	6.87
20.00	2.95	0.00	23.95	1.00	1.19	9.79	6.97	6.97
30.00	2.91	0.00	23.95	1.00	1.19	9.79	6.92	6.92
40.00	2.91	0.00	23.95	1.00	1.19	9.79	6.92	6.92
50.00	2.73	0.00	23.95	1.00	1.19	9.79	6.71	6.71
60.00	2.91	0.00	23.95	1.00	1.19	9.79	6.92	6.92
70.00	2.86	0.00	23.95	1.00	1.19	9.79	6.87	6.87
80.00	2.86	0.00	23.95	1.00	1.19	9.79	6.87	6.87
90.00	2.86	0.00	23.95	1.00	1.19	9.79	6.87	6.87
100.00	2.91	0.00	23.95	1.00	1.19	9.79	6.92	6.92
110.00	2.86	0.00	23.95	1.00	1.19	9.79	6.87	6.87
120.00	2.86	0.00	23.95	1.00	1.19	9.79	6.87	6.87
130.00	2.91	0.00	23.95	1.00	1.19	9.79	6.92	6.92
140.00	3.00	0.00	23.95	1.00	1.19	9.79	7.02	7.02
150.00	2.86	0.00	23.95	1.00	1.19	9.79	6.87	6.87
160.00	2.86	0.00	23.95	1.00	1.19	9.79	6.87	6.87
170.00	2.82	0.00	23.95	1.00	1.19	9.79	6.82	6.82
180.00	2.86	0.00	23.95	1.00	1.19	9.79	6.87	6.87
190.00	2.91	0.00	23.95	1.00	1.19	9.79	6.92	6.92
200.00	2.91	0.00	23.95	1.00	1.19	9.79	6.92	6.92
210.00	2.95	0.00	23.95	1.00	1.19	9.79	6.97	6.97
220.00	2.95	0.00	23.95	1.00	1.19	9.79	6.97	6.97
230.00	2.95	0.00	23.95	1.00	1.19	9.79	6.97	6.97
240.00	2.91	0.00	23.95	1.00	1.19	9.79	6.92	6.92
250.00	2.91	0.00	23.95	1.00	1.19	9.79	6.92	6.92
260.00	3.00	0.00	23.95	1.00	1.19	9.79	7.02	7.02
270.00	2.86	0.00	23.95	1.00	1.19	9.79	6.87	6.87
280.00	2.82	0.00	23.95	1.00	1.19	9.79	6.82	6.82
290.00	2.82	0.00	23.95	1.00	1.19	9.79	6.82	6.82
300.00	2.95	0.00	23.95	1.00	1.19	9.79	6.97	6.97

Tunnel and Tip velocity for 40% wind speed

Time [s]	Head H11 [mm]	Head H12 [mm]	Ambient Temperature t [°C]	Water Density [kg/m^3]	Air Density [kg/m^3]	g [m/s^2]	Tunnel Velocity [m/s]	Tip Velocity [m/s]
0.00	10.37	0.04	23.93	1.00	1.19	9.79	13.07	13.04
10.00	10.24	0.00	23.93	1.00	1.19	9.79	12.99	12.99
20.00	10.42	0.04	23.93	1.00	1.19	9.79	13.10	13.07
30.00	10.42	0.04	23.93	1.00	1.19	9.79	13.10	13.07
40.00	10.42	0.00	23.93	1.00	1.19	9.79	13.10	13.10
50.00	10.55	0.04	23.93	1.00	1.19	9.79	13.18	13.15
60.00	10.20	0.00	23.93	1.00	1.19	9.79	12.96	12.96
70.00	10.33	0.00	23.93	1.00	1.19	9.79	13.04	13.04
80.00	10.46	0.04	23.93	1.00	1.19	9.79	13.13	13.10
90.00	10.37	0.00	23.93	1.00	1.19	9.79	13.07	13.07
100.00	10.50	0.09	23.93	1.00	1.19	9.79	13.15	13.10
110.00	10.64	0.09	23.93	1.00	1.19	9.79	13.23	13.18
120.00	10.24	0.04	23.93	1.00	1.19	9.79	12.99	12.96
130.00	10.55	0.09	23.93	1.00	1.19	9.79	13.18	13.13
140.00	10.55	0.09	23.93	1.00	1.19	9.79	13.18	13.13
150.00	10.42	0.04	23.93	1.00	1.19	9.79	13.10	13.07
160.00	10.03	0.00	23.93	1.00	1.19	9.79	12.85	12.85
170.00	10.33	0.00	23.93	1.00	1.19	9.79	13.04	13.04
180.00	10.03	0.00	23.93	1.00	1.19	9.79	12.85	12.85
190.00	10.07	0.04	23.93	1.00	1.19	9.79	12.88	12.85
200.00	10.59	0.04	23.93	1.00	1.19	9.79	13.21	13.18
210.00	10.37	0.09	23.93	1.00	1.19	9.79	13.07	13.02
220.00	10.16	0.00	23.93	1.00	1.19	9.79	12.93	12.93
230.00	10.59	0.04	23.93	1.00	1.19	9.79	13.21	13.18
240.00	10.29	0.04	23.93	1.00	1.19	9.79	13.02	12.99
250.00	10.50	0.04	23.93	1.00	1.19	9.79	13.15	13.13
260.00	10.42	0.09	23.93	1.00	1.19	9.79	13.10	13.04
270.00	10.37	0.00	23.93	1.00	1.19	9.79	13.07	13.07
280.00	10.20	0.04	23.93	1.00	1.19	9.79	12.96	12.93
290.00	10.24	0.00	23.93	1.00	1.19	9.79	12.99	12.99
300.00	10.50	0.04	23.93	1.00	1.19	9.79	13.15	13.13

Tunnel and Tip velocity for 60% wind speed

Time [s]	Head H11 [mm]	Head H12 [mm]	Ambient Temperature t [°C]	Water Density [kg/m^3]	Air Density [kg/m^3]	g [m/s^2]	Tunnel Velocity [m/s]	Tip Velocity [m/s]
0.00	21.36	0.30	23.89	1.00	1.19	9.79	18.75	18.62
10.00	22.05	0.17	23.89	1.00	1.19	9.79	19.05	18.98
20.00	21.18	0.13	23.89	1.00	1.19	9.79	18.68	18.62
30.00	21.70	0.17	23.89	1.00	1.19	9.79	18.90	18.83
40.00	21.44	0.22	23.89	1.00	1.19	9.79	18.79	18.69
50.00	21.36	0.22	23.89	1.00	1.19	9.79	18.75	18.66
60.00	21.27	0.26	23.89	1.00	1.19	9.79	18.71	18.60
70.00	22.14	0.22	23.89	1.00	1.19	9.79	19.09	19.00
80.00	21.88	0.35	23.89	1.00	1.19	9.79	18.98	18.83
90.00	21.49	0.26	23.89	1.00	1.19	9.79	18.81	18.69
100.00	22.09	0.26	23.89	1.00	1.19	9.79	19.07	18.96
110.00	22.09	0.26	23.89	1.00	1.19	9.79	19.07	18.96
120.00	21.23	0.13	23.89	1.00	1.19	9.79	18.69	18.64
130.00	21.14	0.17	23.89	1.00	1.19	9.79	18.66	18.58
140.00	21.53	0.26	23.89	1.00	1.19	9.79	18.83	18.71
150.00	21.66	0.22	23.89	1.00	1.19	9.79	18.88	18.79
160.00	21.66	0.17	23.89	1.00	1.19	9.79	18.88	18.81
170.00	21.53	0.30	23.89	1.00	1.19	9.79	18.83	18.69
180.00	21.70	0.26	23.89	1.00	1.19	9.79	18.90	18.79
190.00	21.92	0.13	23.89	1.00	1.19	9.79	19.00	18.94
200.00	21.62	0.17	23.89	1.00	1.19	9.79	18.87	18.79
210.00	21.62	0.17	23.89	1.00	1.19	9.79	18.87	18.79
220.00	21.79	0.22	23.89	1.00	1.19	9.79	18.94	18.85
230.00	21.66	0.30	23.89	1.00	1.19	9.79	18.88	18.75
240.00	21.53	0.13	23.89	1.00	1.19	9.79	18.83	18.77
250.00	21.79	0.22	23.89	1.00	1.19	9.79	18.94	18.85
260.00	21.23	0.17	23.89	1.00	1.19	9.79	18.69	18.62
270.00	21.27	0.17	23.89	1.00	1.19	9.79	18.71	18.64
280.00	20.88	0.09	23.89	1.00	1.19	9.79	18.54	18.50
290.00	20.01	0.17	23.89	1.00	1.19	9.79	18.15	18.07
300.00	21.62	0.22	23.89	1.00	1.19	9.79	18.87	18.77
310.00	21.75	0.30	23.89	1.00	1.19	9.79	18.92	18.79
320.00	21.66	0.22	23.89	1.00	1.19	9.79	18.88	18.79
330.00	21.53	0.22	23.89	1.00	1.19	9.79	18.83	18.73
340.00	21.70	0.17	23.89	1.00	1.19	9.79	18.90	18.83
350.00	21.36	0.22	23.89	1.00	1.19	9.79	18.75	18.66
360.00	21.53	0.22	23.89	1.00	1.19	9.79	18.83	18.73
370.00	21.92	0.26	23.89	1.00	1.19	9.79	19.00	18.88
380.00	21.44	0.22	23.89	1.00	1.19	9.79	18.79	18.69
390.00	21.57	0.13	23.89	1.00	1.19	9.79	18.85	18.79
400.00	21.92	0.17	23.89	1.00	1.19	9.79	19.00	18.92
410.00	21.27	0.17	23.89	1.00	1.19	9.79	18.71	18.64
420.00	21.70	0.17	23.89	1.00	1.19	9.79	18.90	18.83
430.00	21.88	0.22	23.89	1.00	1.19	9.79	18.98	18.88
440.00	21.40	0.22	23.89	1.00	1.19	9.79	18.77	18.68
450.00	21.53	0.22	23.89	1.00	1.19	9.79	18.83	18.73
460.00	22.01	0.22	23.89	1.00	1.19	9.79	19.04	18.94
470.00	21.10	0.17	23.89	1.00	1.19	9.79	18.64	18.56
480.00	21.66	0.22	23.89	1.00	1.19	9.79	18.88	18.79
490.00	21.57	0.13	23.89	1.00	1.19	9.79	18.85	18.79
500.00	21.49	0.22	23.89	1.00	1.19	9.79	18.81	18.71
510.00	21.96	0.22	23.89	1.00	1.19	9.79	19.02	18.92
520.00	21.96	0.30	23.89	1.00	1.19	9.79	19.02	18.88
530.00	21.57	0.17	23.89	1.00	1.19	9.79	18.85	18.77
540.00	21.23	0.17	23.89	1.00	1.19	9.79	18.69	18.62
550.00	21.44	0.17	23.89	1.00	1.19	9.79	18.79	18.71
560.00	21.57	0.26	23.89	1.00	1.19	9.79	18.85	18.73
570.00	21.75	0.26	23.89	1.00	1.19	9.79	18.92	18.81
580.00	21.36	0.17	23.89	1.00	1.19	9.79	18.75	18.68
590.00	20.27	0.09	23.89	1.00	1.19	9.79	18.27	18.23
600.00	21.75	0.26	23.89	1.00	1.19	9.79	18.92	18.81

Tunnel and Tip velocity for 80% wind speed

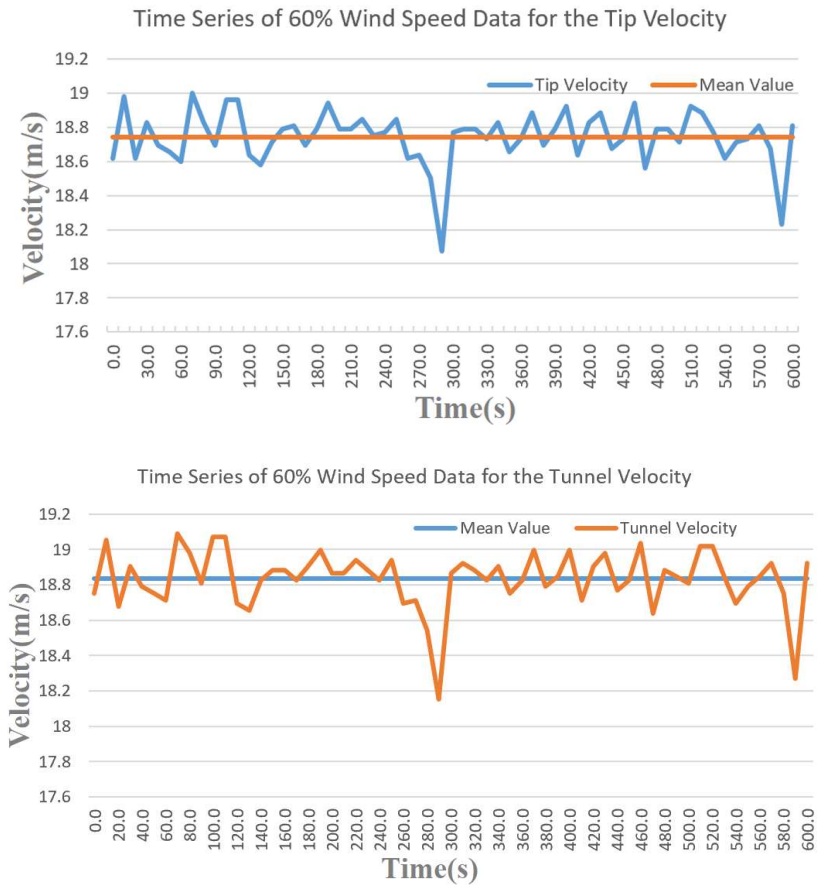
Time [s]	Head H11 [mm]	Head H12 [mm]	Ambient Temperature t [°C]	Water Density [kg/m^3]	Air Density [kg/m^3]	g [m/s^2]	Tunnel Velocity [m/s]	Tip Velocity [m/s]
0.00	38.85	0.35	24.32	1.00	1.19	9.79	25.31	25.20
10.00	37.94	0.48	24.32	1.00	1.19	9.79	25.01	24.85
20.00	38.03	0.52	24.32	1.00	1.19	9.79	25.04	24.87
30.00	38.68	0.43	24.32	1.00	1.19	9.79	25.25	25.11
40.00	38.46	0.43	24.32	1.00	1.19	9.79	25.18	25.04
50.00	38.55	0.56	24.32	1.00	1.19	9.79	25.21	25.03
60.00	38.29	0.65	24.32	1.00	1.19	9.79	25.13	24.91
70.00	38.20	0.48	24.32	1.00	1.19	9.79	25.10	24.94
80.00	38.11	0.35	24.32	1.00	1.19	9.79	25.07	24.95
90.00	38.76	0.43	24.32	1.00	1.19	9.79	25.28	25.14
100.00	37.63	0.56	24.32	1.00	1.19	9.79	24.91	24.72
110.00	38.03	0.43	24.32	1.00	1.19	9.79	25.04	24.90
120.00	39.15	0.56	24.32	1.00	1.19	9.79	25.41	25.22
130.00	38.72	0.65	24.32	1.00	1.19	9.79	25.27	25.05
140.00	37.85	0.43	24.32	1.00	1.19	9.79	24.98	24.84
150.00	38.42	0.74	24.32	1.00	1.19	9.79	25.17	24.92
160.00	37.63	0.65	24.32	1.00	1.19	9.79	24.91	24.69
170.00	38.07	0.52	24.32	1.00	1.19	9.79	25.05	24.88
180.00	37.77	0.43	24.32	1.00	1.19	9.79	24.95	24.81
190.00	37.81	0.35	24.32	1.00	1.19	9.79	24.97	24.85
200.00	38.72	0.56	24.32	1.00	1.19	9.79	25.27	25.08
210.00	38.98	0.39	24.32	1.00	1.19	9.79	25.35	25.22
220.00	37.98	0.52	24.32	1.00	1.19	9.79	25.03	24.85
230.00	37.20	0.48	24.32	1.00	1.19	9.79	24.77	24.61
240.00	38.46	0.61	24.32	1.00	1.19	9.79	25.18	24.98
250.00	38.55	0.56	24.32	1.00	1.19	9.79	25.21	25.03
260.00	38.89	0.48	24.32	1.00	1.19	9.79	25.32	25.17
270.00	38.98	0.43	24.32	1.00	1.19	9.79	25.35	25.21
280.00	37.77	0.35	24.32	1.00	1.19	9.79	24.95	24.84
290.00	38.29	0.48	24.32	1.00	1.19	9.79	25.13	24.97
300.00	37.98	0.39	24.32	1.00	1.19	9.79	25.03	24.90
310.00	38.81	0.48	24.32	1.00	1.19	9.79	25.30	25.14
320.00	37.24	0.52	24.32	1.00	1.19	9.79	24.78	24.61
330.00	37.94	0.39	24.32	1.00	1.19	9.79	25.01	24.88
340.00	37.81	0.43	24.32	1.00	1.19	9.79	24.97	24.82
350.00	38.85	0.56	24.32	1.00	1.19	9.79	25.31	25.13
360.00	38.29	0.48	24.32	1.00	1.19	9.79	25.13	24.97
370.00	38.68	0.43	24.32	1.00	1.19	9.79	25.25	25.11
380.00	37.81	0.56	24.32	1.00	1.19	9.79	24.97	24.78
390.00	38.29	0.48	24.32	1.00	1.19	9.79	25.13	24.97
400.00	37.94	0.48	24.32	1.00	1.19	9.79	25.01	24.85
410.00	38.81	0.61	24.32	1.00	1.19	9.79	25.30	25.10
420.00	38.11	0.52	24.32	1.00	1.19	9.79	25.07	24.90
430.00	38.16	0.52	24.32	1.00	1.19	9.79	25.08	24.91
440.00	38.94	0.52	24.32	1.00	1.19	9.79	25.34	25.17
450.00	38.33	0.43	24.32	1.00	1.19	9.79	25.14	25.00
460.00	37.55	0.48	24.32	1.00	1.19	9.79	24.88	24.72
470.00	37.55	0.48	24.32	1.00	1.19	9.79	24.88	24.72
480.00	38.68	0.39	24.32	1.00	1.19	9.79	25.25	25.13
490.00	38.98	0.43	24.32	1.00	1.19	9.79	25.35	25.21
500.00	38.81	0.48	24.32	1.00	1.19	9.79	25.30	25.14
510.00	37.85	0.39	24.32	1.00	1.19	9.79	24.98	24.85
520.00	38.20	0.39	24.32	1.00	1.19	9.79	25.10	24.97
530.00	38.33	0.35	24.32	1.00	1.19	9.79	25.14	25.03
540.00	39.11	0.65	24.32	1.00	1.19	9.79	25.39	25.18
550.00	39.20	0.43	24.32	1.00	1.19	9.79	25.42	25.28
560.00	38.50	0.56	24.32	1.00	1.19	9.79	25.20	25.01
570.00	38.55	0.43	24.32	1.00	1.19	9.79	25.21	25.07
580.00	37.63	0.61	24.32	1.00	1.19	9.79	24.91	24.71
590.00	38.24	0.39	24.32	1.00	1.19	9.79	25.11	24.98
600.00	38.85	0.61	24.32	1.00	1.19	9.79	25.31	25.11

Tunnel and Tip velocity for 100% wind speed

Time [s]	Head H11 [mm]	Head H12 [mm]	Ambient Temperature t [°C]	Water Density [kg/m^3]	Air Density [kg/m^3]	g [m/s^2]	Tunnel Velocity [m/s]	Tip Velocity [m/s]
0.00	61.51	0.56	24.29	1.00	1.19	9.79	31.84	31.70
10.00	62.68	1.00	24.29	1.00	1.19	9.79	32.15	31.89
20.00	62.42	0.82	24.29	1.00	1.19	9.79	32.08	31.87
30.00	62.25	0.82	24.29	1.00	1.19	9.79	32.04	31.82
40.00	61.81	0.91	24.29	1.00	1.19	9.79	31.92	31.69
50.00	61.29	0.91	24.29	1.00	1.19	9.79	31.79	31.55
60.00	61.94	0.91	24.29	1.00	1.19	9.79	31.96	31.72
70.00	61.81	0.82	24.29	1.00	1.19	9.79	31.92	31.71
80.00	61.21	0.65	24.29	1.00	1.19	9.79	31.77	31.60
90.00	62.81	1.04	24.29	1.00	1.19	9.79	32.18	31.91
100.00	61.94	0.91	24.29	1.00	1.19	9.79	31.96	31.72
110.00	59.90	0.78	24.29	1.00	1.19	9.79	31.43	31.22
120.00	62.42	0.78	24.29	1.00	1.19	9.79	32.08	31.88
130.00	60.55	0.87	24.29	1.00	1.19	9.79	31.60	31.37
140.00	61.94	0.74	24.29	1.00	1.19	9.79	31.96	31.77
150.00	60.77	1.17	24.29	1.00	1.19	9.79	31.65	31.35
160.00	61.60	0.82	24.29	1.00	1.19	9.79	31.87	31.65
170.00	62.46	0.82	24.29	1.00	1.19	9.79	32.09	31.88
180.00	61.51	0.91	24.29	1.00	1.19	9.79	31.84	31.61
190.00	61.12	0.78	24.29	1.00	1.19	9.79	31.74	31.54
200.00	61.94	1.00	24.29	1.00	1.19	9.79	31.96	31.70
210.00	61.55	0.82	24.29	1.00	1.19	9.79	31.86	31.64
220.00	60.99	0.78	24.29	1.00	1.19	9.79	31.71	31.51
230.00	61.94	0.87	24.29	1.00	1.19	9.79	31.96	31.73
240.00	61.90	1.09	24.29	1.00	1.19	9.79	31.95	31.66
250.00	61.38	0.82	24.29	1.00	1.19	9.79	31.81	31.60
260.00	62.29	0.87	24.29	1.00	1.19	9.79	32.05	31.82
270.00	60.86	1.00	24.29	1.00	1.19	9.79	31.68	31.41
280.00	61.21	0.52	24.29	1.00	1.19	9.79	31.77	31.63
290.00	59.77	0.95	24.29	1.00	1.19	9.79	31.39	31.14
300.00	61.64	0.82	24.29	1.00	1.19	9.79	31.88	31.66
310.00	61.55	0.61	24.29	1.00	1.19	9.79	31.86	31.70
320.00	61.68	0.87	24.29	1.00	1.19	9.79	31.89	31.66
330.00	60.95	0.74	24.29	1.00	1.19	9.79	31.70	31.51
340.00	60.77	1.13	24.29	1.00	1.19	9.79	31.65	31.36
350.00	61.73	0.52	24.29	1.00	1.19	9.79	31.90	31.77
360.00	61.94	0.87	24.29	1.00	1.19	9.79	31.96	31.73
370.00	60.73	1.00	24.29	1.00	1.19	9.79	31.64	31.38
380.00	60.81	0.65	24.29	1.00	1.19	9.79	31.66	31.49
390.00	61.29	0.91	24.29	1.00	1.19	9.79	31.79	31.55
400.00	61.38	0.78	24.29	1.00	1.19	9.79	31.81	31.61
410.00	60.16	0.82	24.29	1.00	1.19	9.79	31.49	31.28
420.00	61.99	1.00	24.29	1.00	1.19	9.79	31.97	31.71
430.00	61.99	1.00	24.29	1.00	1.19	9.79	31.97	31.71
440.00	60.77	0.82	24.29	1.00	1.19	9.79	31.65	31.44
450.00	61.03	0.74	24.29	1.00	1.19	9.79	31.72	31.53
460.00	61.42	0.78	24.29	1.00	1.19	9.79	31.82	31.62
470.00	61.16	0.87	24.29	1.00	1.19	9.79	31.75	31.53
480.00	61.03	0.65	24.29	1.00	1.19	9.79	31.72	31.55
490.00	62.25	0.69	24.29	1.00	1.19	9.79	32.04	31.86
500.00	61.81	0.74	24.29	1.00	1.19	9.79	31.92	31.73
510.00	60.86	0.69	24.29	1.00	1.19	9.79	31.68	31.49
520.00	62.07	0.78	24.29	1.00	1.19	9.79	31.99	31.79
530.00	61.47	0.78	24.29	1.00	1.19	9.79	31.83	31.63
540.00	61.21	0.78	24.29	1.00	1.19	9.79	31.77	31.56
550.00	61.08	0.69	24.29	1.00	1.19	9.79	31.73	31.55
560.00	61.68	0.95	24.29	1.00	1.19	9.79	31.89	31.64
570.00	62.16	0.56	24.29	1.00	1.19	9.79	32.01	31.87
580.00	61.03	0.82	24.29	1.00	1.19	9.79	31.72	31.51
590.00	60.68	1.04	24.29	1.00	1.19	9.79	31.63	31.36
600.00	60.95	0.78	24.29	1.00	1.19	9.79	31.70	31.49

the data is not enough

Refer to Figure 4, plot the time series of 60% wind speed data for the tunnel and tip velocity.



2．Calculate the mean hot wire voltage for each wind speed.

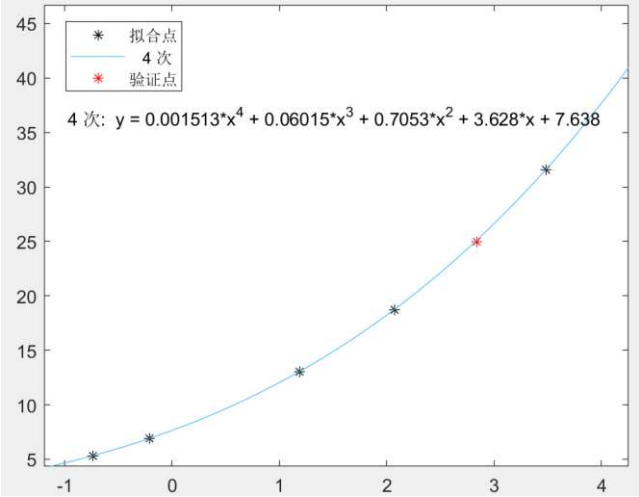
Wind Speed	Mean Hot Wire Voltage
15% Wind Speed	-0.734
20% Wind Speed	-0.213
40% Wind Speed	1.187
60% Wind Speed	2.072
80% Wind Speed	2.839
100% Wind Speed	3.483

3．Calculate the mean tunnel and Tip (Pitot tube) velocity.

Wind Speed	Mean Tunnel Velocity [m/s]	Mean Tip Velocity [m/s]
15% Wind Speed	5.33	5.33
20% Wind Speed	6.90	6.90
40% Wind Speed	13.07	13.04
60% Wind Speed	18.83	18.74
80% Wind Speed	25.13	24.97
100% Wind Speed	31.83	31.62

这组数据计算有些问题

4．Calibrate the hot wire using the mean voltage and mean tip velocity with 15%, 20%, 40%, 60%, and 100% wind speed data using 4^{th}-degree polynomial fitting.



Check the fitting result with the 80% wind speed data.

Namely, x=2.839,

and we get y=0.001513*2.839^4+0.06015*2.839^3+3.628*2.839+7.638=25.097

which is very close to the tip velocity value of 24.97 according to the above chart.

5．Fill out the form below

Fan Speed (%)	Ambient Temperature t [°C]	Tunnel Velocity [m/s]	Turbulence Intensity (by static head)	Tip Velocity [m/s]	Turbulence Intensity (by Pitot tube)	Turbulence Intensity (by hot wire)
15	23.83	5.33	0.008423	5.33	0.008423	0.008374
20	23.95	6.90	0.009668	6.90	0.009668	0.009112
40	23.93	13.07	0.007998	13.04	0.007231	0.01077
60	23.95	18.83	0.008800	18.74	0.008404	0.01427
80	24.32	25.13	0.006462	24.97	0.006542	0.01602
100	24.29	31.83	0.005269	31.62	0.005451	0.01589

Part 3 Results Analysis and Discussion

1. In the case of 60% wind speed, the line chart of the measured Tunnel and Tip Velocity changing with time has great fluctuations. The reason may be that when the experimental measurements were conducting, some students passed through or were in the air inlet and outlet of the wind tunnel, which affected the flow field in the wind tunnel and then led to great fluctuations in the measured wind speed.
2. The turbulence intensity measured and calculated by hot-wire anemometer is different from the turbulence intensity measured and calculated by static pressure and pitot tube under the condition of 40% wind speed and above. The reasons may be as follows:

- The amount of data measured by hot-wire anemometer far exceeds that measured by the pitot tube;
- When processing pitot tube data, the temperature selected for each group of data is the average temperature;
- When using hot wire data for fitting, the selected data is the average value, and the number of scatter points is small, so there may be some error in the fitting curve obtained, and the probability of error increases with the large amount of data accumulated.

IV.Questions

1. Discuss the relationship between wind tunnel static pressure and wind speed, sources of error, and suggestions for improvement.

This question is not for Pitot tube

The relationship between wind tunnel static pressure and wind speed:

Since $P_{total} = P_{static} + P_{dynamic}$ and $P_{dynamic} = \frac{1}{2}\rho v^2$

if the total pressure is stable or changes little, the wind speed will increase as the wind tunnel static pressure decreases.

Sources of Error

1) In the process of the experiment, people were walking around the inlet of the wind tunnel, which changed the flow field, and this is the reason why the data from the 60% wind speed test is abnormal.
2) If the calculation is strictly required, the value of water density should be obtained according to the actual temperature, but the value of water density used in the calculation is just 1 kg/m^3.
3) In the experiment, the gravity acceleration value is roughly calculated according to the latitude of the 137 laboratory, and the calculation result may not be accurate.
4) When processing the static pressure and total pressure data collected by the pitot tube, the temperature is set as constant at the average degrees, but the actual temperature cannot be kept constant all the time, so there is some error in the calculation of air density.

Suggestions for improvement

1) During the wind tunnel experiment, the air inlet and outlet of the wind tunnel should be kept open to avoid blocking and affecting the flow field.
2) Each time the static pressure and the total pressure are sampled, the temperature is measured at the same time, so that more accurate air density can be obtained, and thus higher precision results can be obtained.

2．Describe the advantages and disadvantages of the Pitot tube, and give examples of applications in which a Pitot tube or some variant of it is used.

Advantages:

1) A composite pressure tube that can measure the difference between the total and static pressure of the fluid.
2) It is simple in structure, convenient in manufacturing and use, cheap in price, and can achieve high accuracy with sophisticated manufacturing in a certain speed range.
3) It is suited for a variety of environmental conditions, including extremely high temperatures and a wide range of pressures.

Disadvantages:

1) The pitot tube itself can create perturbations to the flow field, which may affect the measurement results.
2) In actual use, the air in the pitot tube and the rubber tube is not easy to be removed, and the flow direction is not easy to realize.
3) The measurement range is limited.

Examples of applications in which a Pitot tube or some variant of it is used.

1) Measure the speed of an aircraft.
2) The static pressure measured by the Pitot tube can also be used as the calculation parameter of the altimeter.
3) The pitot tube can be used to measure the airflow velocity in the ventilation pipe, industrial pipe, and furnace flue.
4) According to the pitot tube principle, people designed the air meter(such as FLY-1), which can automatically detect the air pressure at multiple points and many times, and automatically calculate the air volume.