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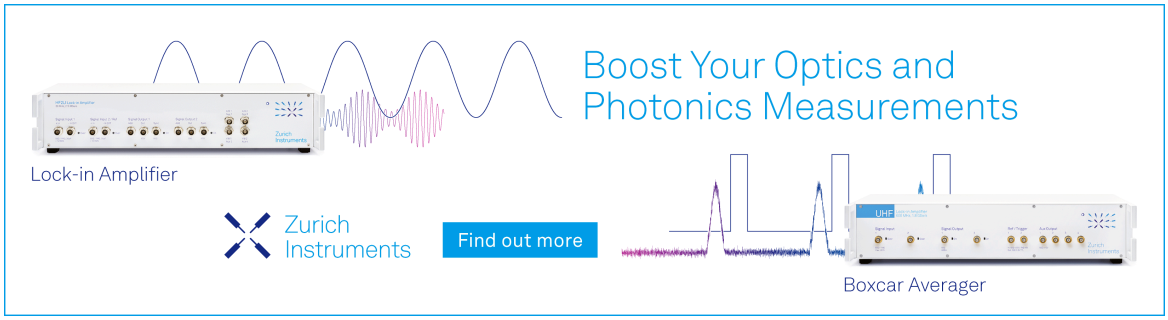
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Methodical Assessment and Truth Flow Analysis of Wind Tunnels

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Abstract. The use of models to test future aircraft, spacecraft, and automobiles are critical, and a wind tunnel is one of the tools used to test models and, in some cases, actual aircraft. Before allowing aircraft and spacecraft to leave the atmosphere, they must be thoroughly tested. The Yaw sphere's systematic and true flow analysis emphasizes the importance of the size and speed of the model. Engineers can use the Yaw sphere to test a range of alternative configurations to improve the performance of aircraft and vehicles in terms of lift, drag force, and fuel economy. Traditionally, research was conducted using apt wind tunnels of various Mach numbers or from the help of numerical analysis, but in the recent scenario, experimental findings are achieved utilizing the wind tunnel test facility. Before testing a model, the rate of maturity and flow frameworks, such as strain, temperature, velocity, flow angularity, density distribution, and turbulence must be checked in the test section. Instead of using a linear technique, the X, Y, and Z approach the flow of plane fields that are used. The tool can be used to analyze the field flow and maturity degree inside the test segment. This report, which may include a data of field flow diagram of test items, further enables the investigation and analysis. As part of this survey, about 3 of South India's wind tunnel's truthfulness is being investigated. For the chosen wind tunnel, a flow framework forecast will be established systematically. The map of data for this flow function will offer decaying velocity and velocity profiles to various ranges of Mach numbers.

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INTRODUCTION

A many-hole velocity probe is a computing device with little holes in the front of the detector and also at the end of the detector. It is used to determine the fluid pressure, static pressure, and overall ambient pressure in fluid flow circumstances where pressure plays an important role in the system's performance [1, 2]. Many-hole pressure probes are extensively used for determining the pressures and flow vectors in the fluid machinery areas because of their resilience, efficiency, and simplicity in the flow computation. When a body is immersed in a fluid flow, the distribution of pressure across its area ranges from a maximum at the point of stagnation to lower values which are occasionally less than the far upstream of static pressure, and the pressure at various positions on its plane is proportional to the magnitude and direction of the velocity flow. This relationship can be regularly enhanced; but, in practice, probes are calibrated experimentally. The most significant aspect of a many-hole pressure probe is its effective and quick calibration. Because the multi-hole probes are modest in size, they may be simply placed into any flowing field without affecting the flow direction [3-5]. A conventional probe has an isolated cylindrical body with numerous holes at its sharp end. For pressure sensing, the holes are joined to the device from the inside. This relation can be routinely enhanced; but, in general practice, probes are calibrated tentatively. When the probe is placed in the flow, our algorithm interprets the pressure computed from all the ports to estimate the probe's magnitude and course. The samples are most commonly used in wind tunnels, towing tanks, and water tunnels, but they've also been found mounted outside of a full-scale wind turbine or inserted into the air intake of an automotive engine prototype, as well as recording industrial activities like mining flotation machines [6-9]. Using appealing three-hole probes, various forms of many-hole probes are used in calculating component velocity in a plane. The

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primary hole of a triple-hole probe is used as a Pitot tube, while the other 2 holes on the left and right sides of the main hole are used for various purposes. The plane's three holes are identical. At least three unaligned holes are required to measure 3D flows, however, one broadly a used 5-hole probe with 2 holes in the identical plane as the center hole and the other 2 in perpendicular planes with the middle hole is sufficient. The 4-hole test has no primary hole, thus there are 2 holes in the horizontal plane & 2 holes' perpendicular to each other.

The odd number of holes normally has the middle point hole and even then a number of holes, the middle holes do not have the sharp end of the probe depending on its structure. Different sorts of samples are utilized in various areas, and it also has the no. of holes made as stated to the criteria, as well as various types of matters are used to produce the sample.

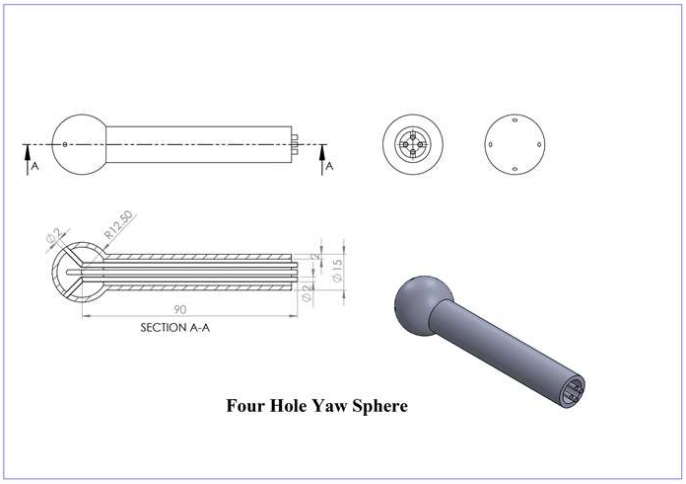


FIGURE 1. 4-hole Yaw Sphere

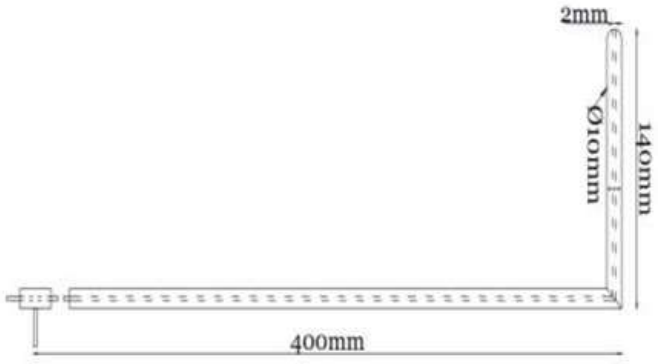


FIGURE 2. Pitot Static Tube

METHODOLOGY AND RESULT ANALYSIS

Methodology

A suitable Pitot and yaw sphere is to be manufactured, taking into account all of the thumb rules and analysis are subsists. As the conditions of the yaw sphere with a diameter of 25 mm and the holes are placed at 90 degrees, the feasible measurements can be acquired but only to 2 degrees positive and negative considering the separation of flow and further be in charge to compute within 0 to 1.3 yaw angles in the overall survey. To establish an organized scheme of the tunnel, those data must be plotted. Moreover, following the comprehension of the trial and error data samples of 450, 650, and 800 revolutions per minute with a range of velocity of 15 to 55 m/s, a velocity profile plot

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was produced. Those plots are obliging for the researchers and students who make use of the tunnel by predetermined profiles and flow angles at various spots.

Result Analysis

Observation-I

TABLE 1. Wind tunnel specification

Organization	Aerozjet
Size of Test Section	600X600 mm
Higher Velocity	80m/s
Reduction Factor	9:1
3 phase AC Power Supply	440 W -64 Amps

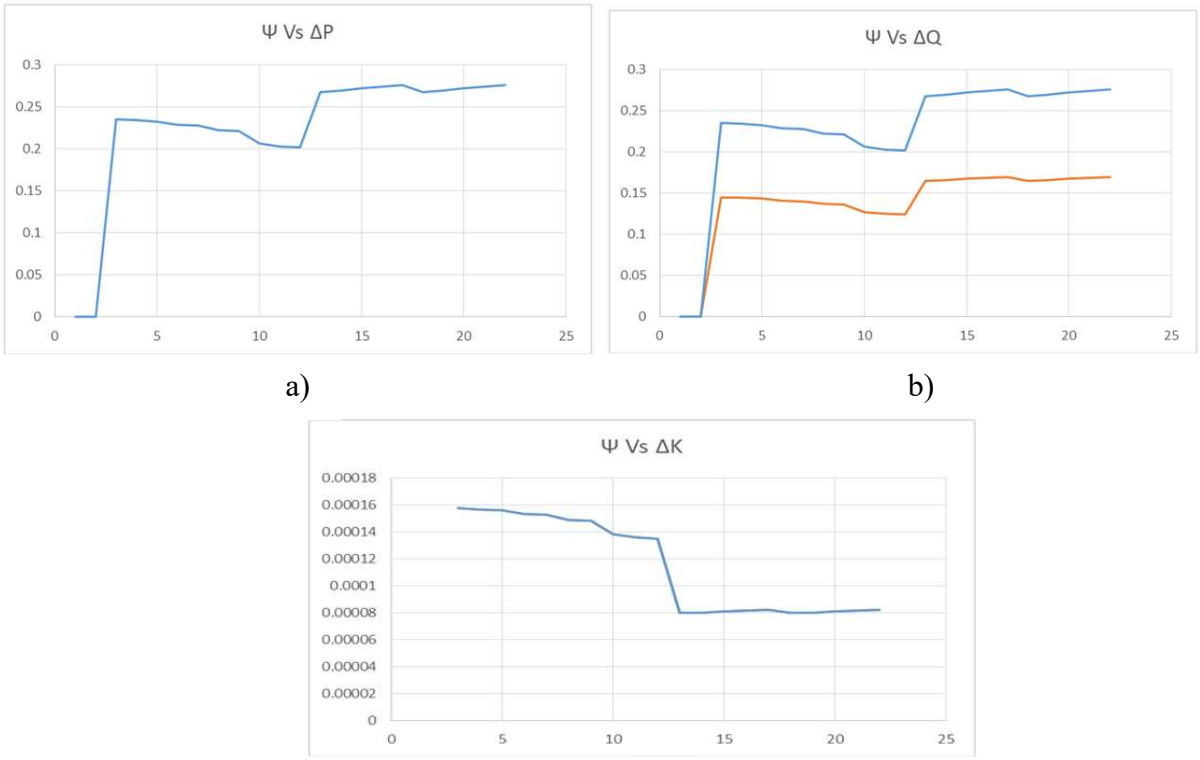


FIGURE 3. (a) Ψ vs ΔP, (b) Ψ vs ΔQ and (c) Ψ vs ΔK

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TABLE 2. Test Result of YAW Sphere in Aerozjet-Wind Tunnel

L (m)	Velocity V	q (P)	Ψ	PA	PB	QA	QB	ΔP = (PA ~PB)	ΔQ = (QA ~QB)	ΔK = (ΔP ~ΔQ)/q
	(m/s)	Pascal					(H2O in cm)			
0.1	30	573.93	0	17.64	17.88	18.48	18.3353	0.2353	0.1448	0.000157685
0.1	30	573.93	0.3	17.55	17.78	18.378	18.234	0.234	0.144	0.000156814
0.1	30	573.93	0.6	17.45	17.68	18.2759	18.1327	0.2327	0.1432	0.000155942
0.1	30	573.93	0.9	17.16	17.38	17.9696	17.8288	0.2288	0.1408	0.000153329
0.1	30	573.93	1.2	17.06	17.29	17.8675	17.7275	0.2275	0.14	0.000152458
0.15	30	573.93	0	16.67	16.89	17.4591	17.3223	0.2223	0.1368	0.000148973
0.15	30	573.93	0.3	16.57	16.79	17.357	17.221	0.221	0.136	0.000148102
0.15	30	573.93	0.6	15.50	15.709	16.2339	16.1067	0.2067	0.1272	0.000138519
0.15	30	573.93	0.9	15.21	15.41	15.9276	15.8028	0.2028	0.1248	0.000135905
0.15	30	573.93	1.2	15.11	15.31	15.8255	15.7015	0.2015	0.124	0.000135034
0.1	45	1291.34	0	20.08	20.35	21.0326	20.8678	0.2678	0.1648	7.98E-05
0.1	45	1291.34	0.3	20.18	20.45	21.1347	20.9691	0.2691	0.1656	8.01E-05
0.1	45	1291.34	0.6	20.37	20.64	21.3389	21.1717	0.2717	0.1672	8.09E-05
0.1	45	1291.34	0.9	20.57	20.84	21.5431	21.3743	0.2743	0.1688	8.17E-05
0.1	45	1291.34	1.2	20.67	20.94	21.6452	21.4756	0.2756	0.1696	8.21E-05
0.15	45	1291.34	0	20.08	20.35	21.0326	20.8678	0.2678	0.1648	7.98E-05
0.15	45	1291.34	0.3	20.18	20.45	21.1347	20.9691	0.2691	0.1656	8.01E-05
0.15	45	1291.34	0.6	20.37	20.64	21.3389	21.1717	0.2717	0.1672	8.09E-05
0.15	45	1291.34	0.9	20.57	20.84	21.5431	21.3743	0.2743	0.1688	8.17E-05
0.15	45	1291.34	1.2	20.67	20.94	21.6452	21.4756	0.2756	0.1696	8.21E-05

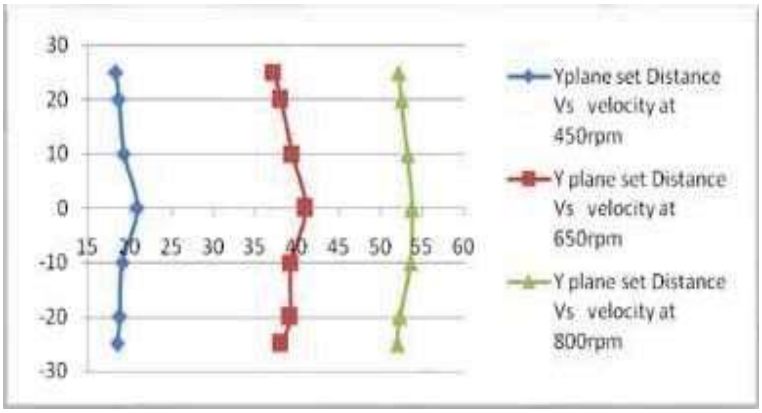


FIGURE 4. Velocity Profile (Y-Axis)

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TABLE 3. Profile of Velocity: using 1- stagnation Pitot tube with 7- static hole

Axis	Distance (cm)	Velocity (m/s)		
		450rpm	650rpm	800rpm
X	25	18.5	37.3	52.3
	20	18.8	38.1	52.9
	10	19	39.3	53.1
	0	21	41	53.8
	-10	19.3	39.5	53.1
	-20	18.7	39.1	52.7
	-25	18.4	38.0	52.1
Y	25	18.3	37.2	52.2
	20	18.7	38.1	52.5
	10	19.3	39.4	53.2
	0	20.9	41	53.8
	-10	19.1	39.3	53.6
	-20	18.8	39.2	52.3
	-25	18.5	38.1	52.0

Observation-II

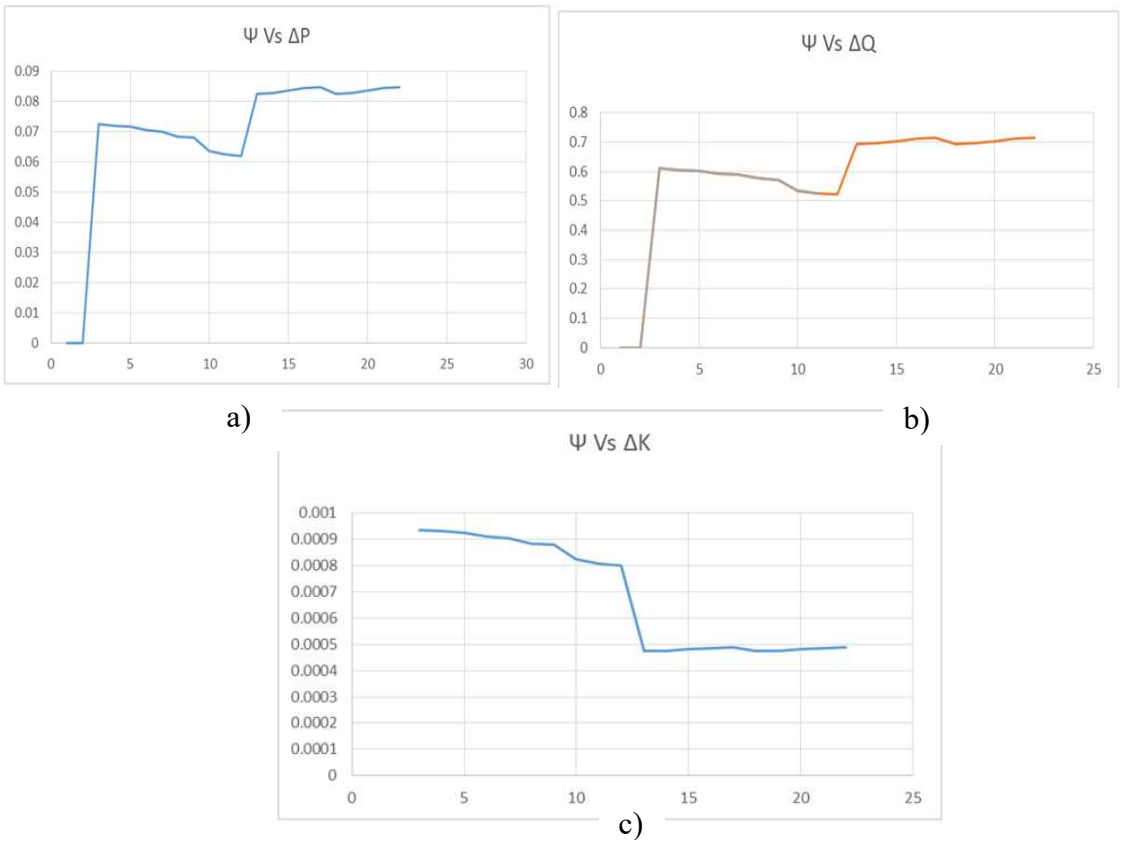


FIGURE 5. (a) Ψ vs ΔP, (b) Ψ vs ΔQ and (c) Ψ vs ΔK

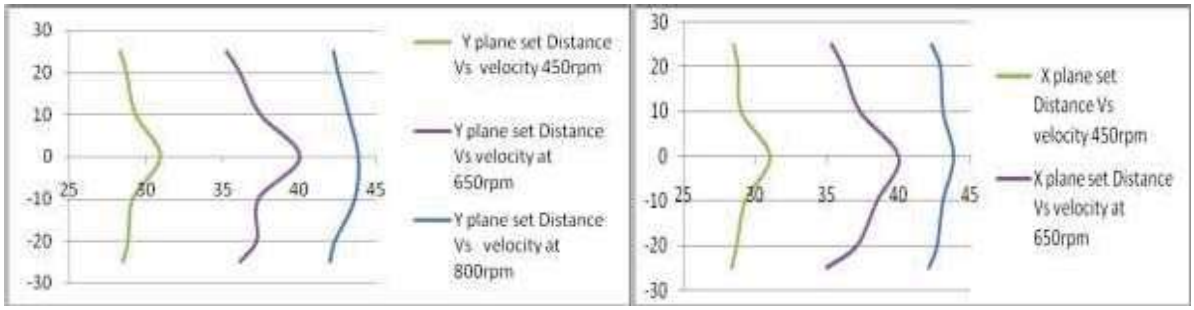
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TABLE 4. Wind tunnel specification

Organization	LIPS Research & DL-Card
Size of Test Section	600X600 mm
Higher Velocity	75 m/s
Reduction Factor	9:1
3 phase AC Power Supply	440 W -64 Amps

TABLE 5. Velocity profile: 1 stagnation Pitot tube & using 7 static holes

Axis	Distance (cm)	Velocity (m/s)		
		450 rpm	650rpm	800rpm
X	25	28.5	35.3	42.3
	20	28.8	36.1	42.9
	10	29	37.3	43.1
	0	31	40	43.8
	-10	29.3	38.5	43.1
	-20	28.7	37.1	42.7
	-25	28.4	35.0	42.1
Y	25	28.3	35.2	42.2
	20	28.7	36.1	42.5
	10	29.3	37.4	43.2
	0	30.9	40	43.8
	-10	29.1	37.3	43.6
	-20	28.8	37.2	42.3
	-25	28.5	36.1	42.0



(a) (b)

FIGURE 6. (a) Velocity profile (X-axis); (b) Velocity profile (Y-axis).

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TABLE 6. Test Result of YAW Sphere in LIPS Research & DL CARD -Wind Tunnel

L (m)	Velocity V	q (P)	Ψ	PA	PB	QA	QB	ΔP = (PA ~PB)	ΔQ = (QA ~QB)	ΔK = (ΔP ~ΔQ)/q
	(m/s)	Pascal				(H_2O in cm)				
0.1	30	573.93	0	17.8647	17.9371	17.87013	18.4801	0.0724	0.60997	0.000937
0.1	30	573.93	0.3	17.766	17.838	17.7714	18.378	0.072	0.6066	0.000931
0.1	30	573.93	0.6	17.6673	17.7389	17.67267	18.2759	0.0716	0.60323	0.000926
0.1	30	573.93	0.9	17.3712	17.4416	17.37648	17.9696	0.0704	0.59312	0.000911
0.1	30	573.93	1.2	17.2725	17.3425	17.27775	17.8675	0.07	0.58975	0.000906
0.15	30	573.93	0	16.8777	16.9461	16.88283	17.4591	0.0684	0.57627	0.000885
0.15	30	573.93	0.3	16.779	16.847	16.7841	17.357	0.068	0.5729	0.00088
0.15	30	573.93	0.6	15.6933	15.7569	15.69807	16.2339	0.0636	0.53583	0.000823
0.15	30	573.93	0.9	15.3972	15.4596	15.40188	15.9276	0.0624	0.52572	0.000807
0.15	30	573.93	1.2	15.2985	15.3605	15.30315	15.8255	0.062	0.52235	0.000802
0.1	45	1291.343	0	20.3322	20.4146	20.33838	21.0326	0.0824	0.69422	0.000474
0.1	45	1291.343	0.3	20.4309	20.5137	20.43711	21.1347	0.0828	0.69759	0.000476
0.1	45	1291.343	0.6	20.6283	20.7119	20.63457	21.3389	0.0836	0.70433	0.000481
0.1	45	1291.343	0.9	20.8257	20.9101	20.83203	21.5431	0.0844	0.71107	0.000485
0.1	45	1291.343	1.2	20.9244	21.0092	20.93076	21.6452	0.0848	0.71444	0.000488
0.15	45	1291.343	0	20.3322	20.4146	20.33838	21.0326	0.0824	0.69422	0.000474
0.15	45	1291.343	0.3	20.4309	20.5137	20.43711	21.1347	0.0828	0.69759	0.000476
0.15	45	1291.343	0.6	20.6283	20.7119	20.63457	21.3389	0.0836	0.70433	0.000481
0.15	45	1291.343	0.9	20.8257	20.9101	20.83203	21.5431	0.0844	0.71107	0.000485
0.15	45	1291.343	1.2	20.9244	21.0092	20.93076	21.6452	0.0848	0.71444	0.000488

Observation-III

TABLE 7. Wind tunnel specification

Organization	Liv In
Size of Test Section	600X600 mm
Higher Velocity	75 m/s
Reduction Factor	9:1
3 phase AC Power Supply	440 W -64 Amps

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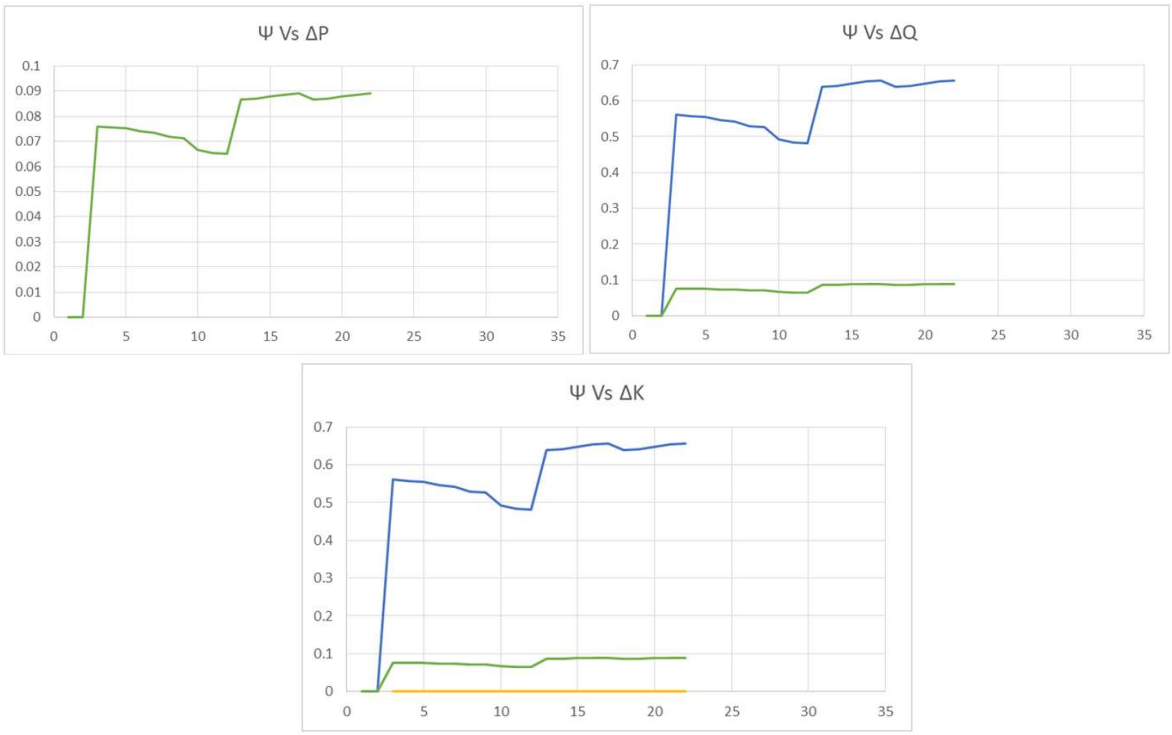
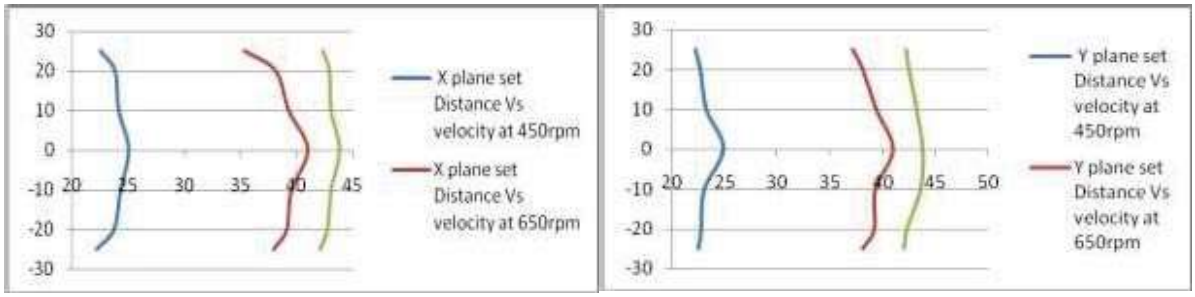


FIGURE 7. Ψ vs ΔP, Ψ vs ΔQ and Ψ vs ΔK



(a) (b)

FIGURE 8. (a) Velocity profile (X-axis); (b) Velocity profile (Y-axis)

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TABLE 8. Test Result of YAW Sphere in Livin -Wind Tunnel

L (m)	Velocity V	q (P)	Ψ	PA	PB	QA	QB	ΔP = (PA ~PB)	ΔQ = (QA ~QB)	ΔK = (ΔP ~ΔQ)/q
	(m/s)	Pascal				(H2O in cm)				
0.1	30	573.93	0	18.0457	18.12172	18.643	18.0819	0.07602	0.5611	0.000845
0.1	30	573.93	0.3	17.946	18.0216	18.54	17.982	0.0756	0.558	0.000841
0.1	30	573.93	0.6	17.8463	17.92148	18.437	17.8821	0.07518	0.5549	0.000836
0.1	30	573.93	0.9	17.5472	17.62112	18.128	17.5824	0.07392	0.5456	0.000822
0.1	30	573.93	1.2	17.4475	17.521	18.025	17.4825	0.0735	0.5425	0.000817
0.15	30	573.93	0	17.0487	17.12052	17.613	17.0829	0.07182	0.5301	0.000798
0.15	30	573.93	0.3	16.949	17.0204	17.51	16.983	0.0714	0.527	0.000794
0.15	30	573.93	0.6	15.8523	15.91908	16.377	15.8841	0.06678	0.4929	0.000742
0.15	30	573.93	0.9	15.5532	15.61872	16.068	15.5844	0.06552	0.4836	0.000728
0.15	30	573.93	1.2	15.4535	15.5186	15.965	15.4845	0.0651	0.4805	0.000724
0.1	45	1291.342	0	20.5382	20.62472	21.218	20.5794	0.08652	0.6386	0.000428
0.1	45	1291.342	0.3	20.6379	20.72484	21.321	20.6793	0.08694	0.6417	0.00043
0.1	45	1291.342	0.6	20.8373	20.92508	21.527	20.8791	0.08778	0.6479	0.000434
0.1	45	1291.342	0.9	21.0367	21.12532	21.733	21.0789	0.08862	0.6541	0.000438
0.1	45	1291.342	1.2	21.1364	21.22544	21.836	21.1788	0.08904	0.6572	0.00044
0.15	45	1291.342	0	20.5382	20.62472	21.218	20.5794	0.08652	0.6386	0.000428
0.15	45	1291.342	0.3	20.6379	20.72484	21.321	20.6793	0.08694	0.6417	0.00043
0.15	45	1291.342	0.6	20.8373	20.92508	21.527	20.8791	0.08778	0.6479	0.000434
0.15	45	1291.342	0.9	21.0367	21.12532	21.733	21.0789	0.08862	0.6541	0.000438
0.15	45	1291.345	1.2	21.1364	21.22544	21.836	21.1788	0.08904	0.6572	0.00044

TABLE 9. Velocity profile: using 1 stagnation Pitot tube 7 static holes

Axis	Distance (cm)	Velocity (m/s)		
		450 rpm	650rpm	800rpm
X	25	22.5	35.3	42.3
	20	23.8	38.1	42.9
	10	24.1	39.3	43.1
	0	25	41	43.8
	-10	24.3	39.5	43.1
	-20	23.7	39.1	42.7
	-25	22.2	38.0	42.1
Y	25	22.3	37.2	42.2
	20	22.7	38.1	42.5
	10	23.3	39.4	43.2
	0	24.9	41	43.8
	-10	23.1	39.3	43.6
	-20	22.8	39.2	42.3
	-25	22.5	38.1	42.0

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CONCLUSION

Three wind tunnels were successfully surveyed in a systematic manner. The turbulence level predicted in all three wind tunnels was found to be quite normal, but little meaningful information was gathered. The results of survey 2 show a rapid increase in the level of turbulence for low speed at the test segment's entry (0.1m from the entry at 20m/s). At the survey -1, the turbulence level was quite high at 0.15m from the entrance at 30m/s, and unanticipated variation of pressure was discovered when examined with the Yaw sphere. The velocity profile was perfectly falling at the side of the wall and in the center of documented highest velocity throughout the study. This report will be extremely beneficial for development, future research, and testing. Our findings have provided a clear picture of the tunnel's true flow and developed data which is plotted on the flow characteristic along the test section axis, as well as the estimated flow of deviations in the form of charts, and, curves, which have been submitted to the appropriate organization.

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