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Design, Construction and Testing Open Circuit Low Speed Wind Tunnel

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***Abstract*: In this paper we are discussing about the Wind Tunnel and its types. The testing chamber is main part of wind tunnel. The construction process is depending on Design parameters and quality of material. In the testing we use the pitot tube, manometer and solid object (airfoil). Solid object is representing the original shape of the object. The Wind Tunnel Testing Machine is used in Aerodynamic research to study the effects of Air moving past to the solid objects. We calculate the velocity of fluid and drag & lift forces. It is use to experimental analysis of object. In this paper we discuss various testing process of object in the wind-tunnel. This paper we discuss the Design, Construction and Testing process open circuit low speed wind tunnel. The Design of wind tunnel is very important to proper working and accuracy of result.**

***Keywords*: Open Circuit Wind Tunnel, Single Testing Section, Wind Tunnel Design, Industrial Design, airfoil analysis.**

1. INTRODUCTION

A wind tunnel is used in aerodynamic research for study the effects of air moving past solid objects. The wind tunnel is very useful for automobiles. In the wind tunnel five important medium are include. First is honeycomb section for proper distribution and air flow. It is an inlet way of air. Second is construction chamber, third is testing chamber, fourth is diffuser section, and last is Motor and fan for outlet of air. The earliest wind tunnel is made 1700 century. It is a primary testing of the designing parts and analysis of the design. It is a very helpful to improve the quality, and manufacturing strength. In the wind tunnel we are testing the parts of automobile, and any mechanical design to improve the shape and design. The main work of the system improves the design according to aerodynamic shapes. The mean of aerodynamic research is reduced the drag and lift forces for batter performance of the parts. Wind tunnel is made to resolve the design parameters. The design of wind tunnel is depend the uses and the velocity ratio of air. It also depend the construction ratio and measurement. The testing chamber is a very important area of wind tunnel. In this area we are testing the part of automobile or mechanical design. The objective shape is depending on the size of wind tunnel. If the testing chamber is short then we are use the prototype model and if the testing chamber is big then we are use the original model. To convert the original shape in the form of prototype model we use the scaling process. In the advanced age of science we make the wind tunnel with the help of engraining graphics. Engraining graphics is an advanced process to make a design and analysis of component. The advanced process of design analysis is CFD and ANSIS. In this process we installed the software in the computer system and make the design and analysis it. It is a not available easily and the learning of this is too tough. The simple type of wind tunnel make easy and its cost is low. In my project I make a wind tunnel for experimental analysis. It is very useful for future research of aerodynamic shapes. [1, 2, 3, 7]

1.1 Types of Wind Tunnel

Wind Tunnel can be classified on the basis of construction as-

a. Open Loop

b. Closed Loop

a. Open Circuit

In an open loop wind tunnel, there is an intake and an exhaust. There is no use for corners and long diffusers but the power needed to drive the wind-tunnel is high because of the loss of energy in the out- flowing air. The open circuit wind tunnel is the simplest and most affordable to build. In these tunnels air is expelled directly into the laboratory and typically reinvested after circulating through the lab, though some tunnels utilize instead a compressed gas source. In addition to their low costs, open circuit tunnels are also advantageous because they have are relatively immune to temperature fluctuations and large disturbances in return flow, provided that the volume of the laboratory is much greater than that of the tunnel. [5]

There are two basic types of open circuit tunnels.

(a)Suck down
(b) Blower

The two are most easily differentiated by the location of the fan. Blower tunnels are the most flexible because the fan is at the inlet of the tunnel, so the test section can be easily interchanged or modified with seriously disrupting flow. These tunnels are so forgiving that exit diffusers can often be completely omitted to allow easier access to test samples and instruments, though the omission often results in a noticeable power loss. Suck down tunnels are typically more susceptible to low frequency unsteadiness in the return flow than blowers, though some claims have been made that intake swirl is less problematic in these tunnels because it does not pass through the fan before entering the test section. [4]

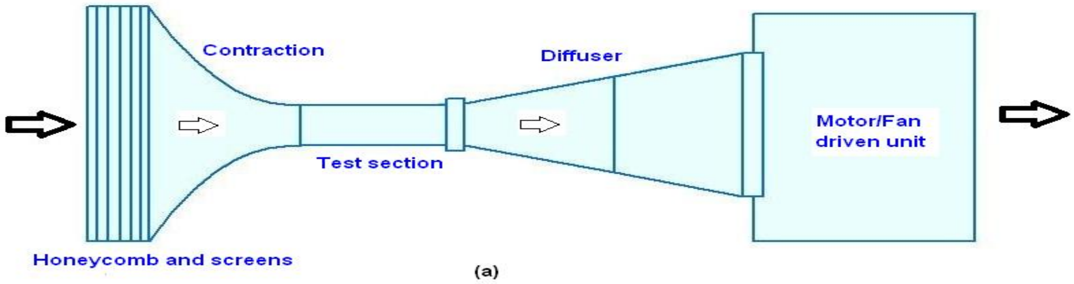


Figure 1: Open Circuit Wind Tunnel Layout

b. Closed Loop

As the name implies, closed circuit tunnels (also called closed return) form an enclosed loop in which exhaust flow is directly returned to the tunnel inlet. In a closed loop wind tunnel, the air is recalculated to improve efficiency for high speed testing. These tunnels are usually larger and more difficult to build. They must be carefully designed in order to maximize uniformity in the return flow. These tunnels are powered by axial fan(s) upstream of the test section and sometime include multistage compressors, which are often necessary to create trans-sonic and supersonic air speeds. Closed circuit wind-tunnels recirculation the air and thus normally need less power to achieve a given low speed, and, above all, facilitate the achievement of well controlled low conditions in the test section. The present, and most low-speed tunnels used for research, are of the closed circuit type. [4]

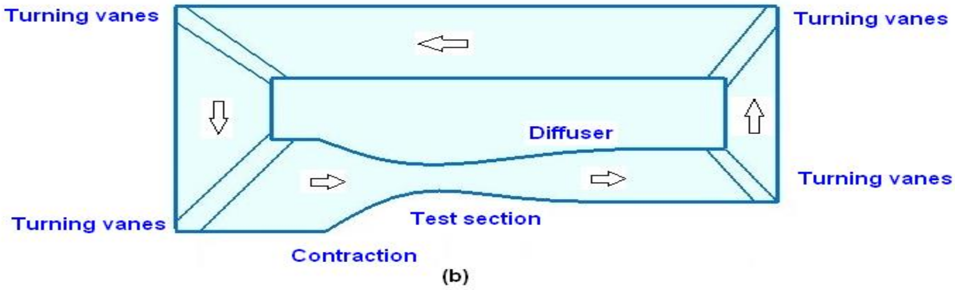


Figure 2: Closed Circuit Wind Tunnel Layout

There are many different kinds of wind tunnels.

- Low-speed wind tunnel
- High-speed wind tunnel
- Supersonic wind tunnel
- Hypersonic wind tunnel
- Subsonic and transonic wind tunnel

2. PROBLEM IDENTIFICATION

This research will focus primarily on the Design and construction process Wind tunnel, flow visualization analysis on an object and calculation of drag coefficient of an object through experiment. It is a very important part to analysis of any part or Design. The cost of wind tunnel is very high. So it is not possible to everyone purchase it easily. My purpose is to resolve primarily problem of making wind tunnel and modify the Design of wind tunnel. My focus is to develop wind tunnel for educational and research purpose. According to previous research study I was found some important area that create problem for making wind tunnel.

2.1 Casting and fabrication

The casting and fabrication of wind tunnel is very expensive. The material and equipments are not available easily. [1, 2, 3, 8, 9]

2.2 Design ratio of each section

The different designs of wind are made different size. Their all section size and length are different. Their ratios are not match according design. The design variation are create problem in the time of fabrication. [1, 2, 7, 8, 9]

2.3 Air will impact the vehicle followed

The pressure of air on the vehicle that followed has not been made clear in earlier researches. That means the pressure of air that moved ahead will naturally hamper the speed of the vehicle that fallowed the first one. This important point is escaped in earlier researches.[8, 15, 16, 18, 20]

2.4 Diffuser set different angles

If the diffuser is set different angles and aerofoil is set basic design, than the effect of profile and drag & lift variation are not clear earlier researches. [3, 4, 8, 9, 11]

3. PROPOSED METHODOLOGY

3.1 Open circuit low speed wind tunnel

Figure 3: Open circuit low speed wind tunnel

- Pitot tube Cv (given) = 0.95
- $\sqrt{2gh}$ = 0.28 (h = 4 mm= .004 m)
- V (velocity middle testing section) = 0.266 m/s
- Fan velocity = 0.353 m/s
- Force of Lift = 3.73 N
- Coefficient of lift = 0.746
- Force of Drag = 0.20 N
- Coefficient of drag = 0.04
- Density of air at 28ºC temperature (ρ) = 1.1839 (kg/m^-3)
- Date of reading = 21-11-2014
- Reynolds number = 2.56 x 10^5
- Mach number = 0.008

3.2 Streamline body testing

The mostly four and two vehicle shape is aerodynamic. I have selected 120 mm length of object. It is made by timber. The resin is select length 120 mm is scaling of another object. The specification of object is given below.

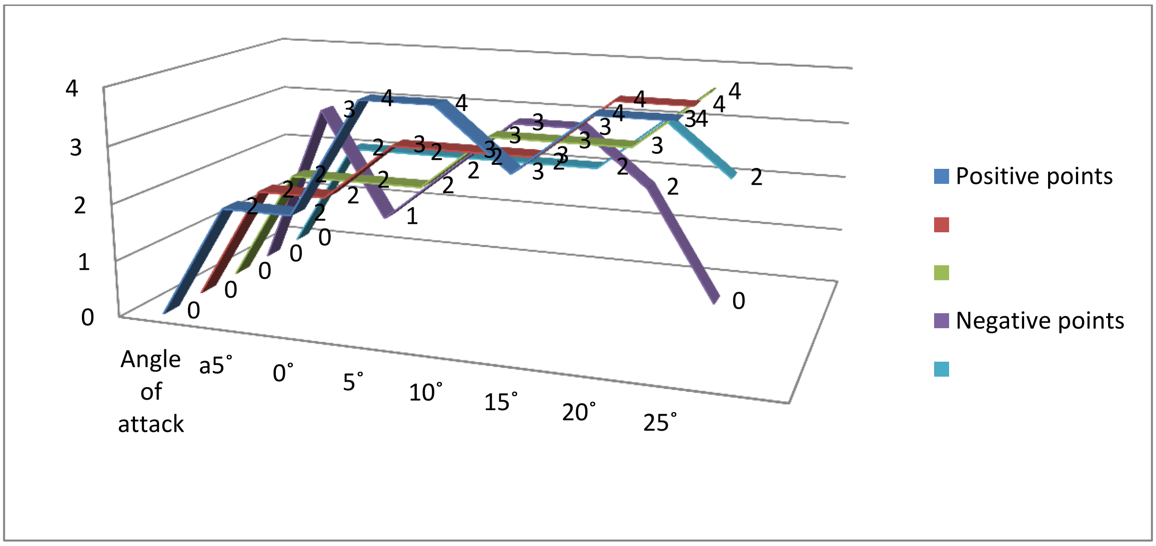
Condition – The diffuser is set different angles but object is constant. The purpose of this test is, when the diffuser is set different angles, than the velocity is increase or not on the testing section. And also find the drag and lift forces variation. What is the growth of boundary layer?

Figure 4: Streamline body Testing

Table 1: Positive and negative readings different angles

S. No	Angle of attack	Manometer Readings(mm)				
		P-1	P-2	P-3	N-1	N-2
1	-5°	2	2	3	3	2
2	0°	2	2	2	1	2
3	5°	4	3	2	2	2
4	10°	4	3	3	3	2
5	15°	3	3	3	3	2
6	20°	4	4	3	2	3
7	25°	4	4	4	0	2

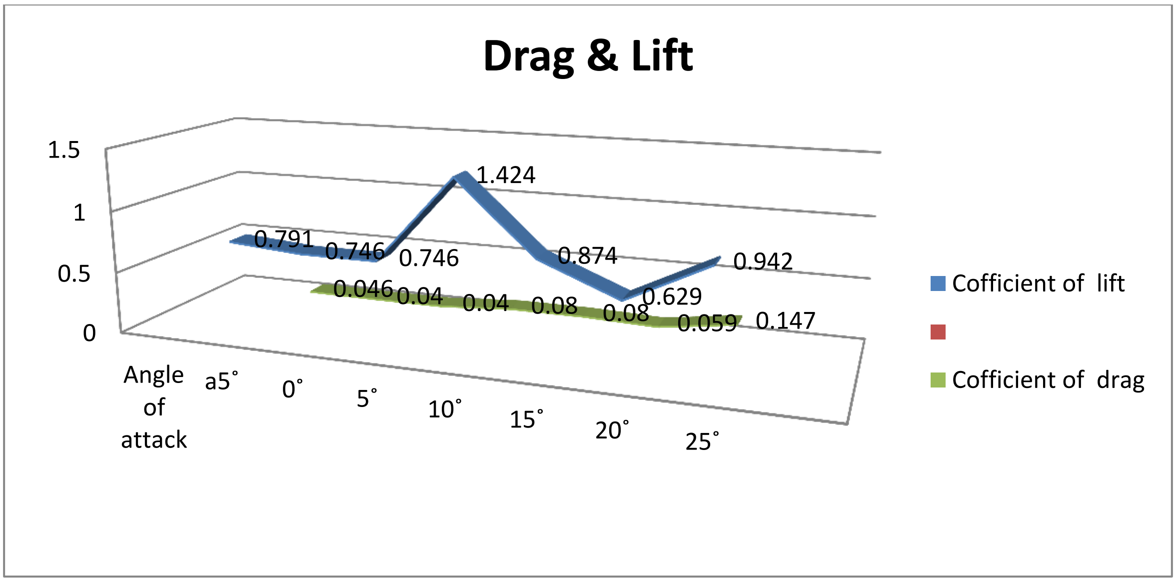
After the testing object I have note all readings carefully. One point I have noticed, if we change the setting diffuser upward and downward, than in upward position the pressure is increased and the negative point is descries. If we set the diffuser downward position then the pressure is descries and the negative point/pressure is increased. The performance of the airfoil is batter 15˚ angle of attack.



Graph 1: Positive & negative pressure

Table 2: Drag and lift force readings different angles.

S. No.	Angle of attack	Drag force (N)	CD	Lift force (N)	CL
1	-5°	0.23	0.046	3.953	0.791
2	0°	0.20	0.04	3.727	0.746
3	5°	0.20	0.04	3.727	0.746
4	10°	0.149	0.030	7.122	1.424
5	15°	0.412	0.08	4.368	0.874
6	20°	0.294	0.059	3.139	0.629
7	25°	0.735	0.147	4.71	0.942



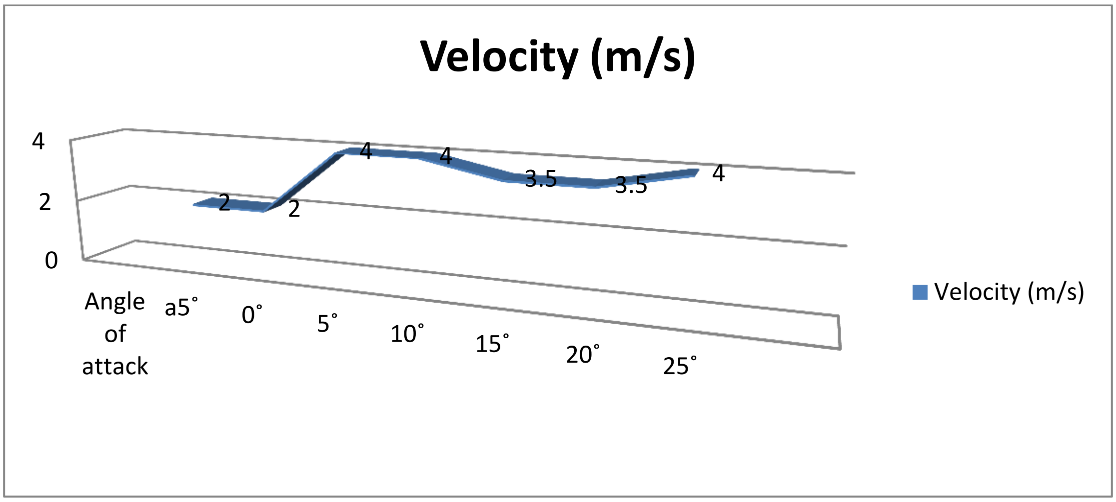
Graph 2: Drag & lift coefficient

S. No.	Angle of attack	Pitot tube and manometer reading (mm)	V (m/s)
1	-5°	2	0.188
2	0°	2	0.188
3	5°	4	0.266
4	10°	4	0.266
5	15°	3.5	0.249
6	20°	3.5	0.249
7	25°	4	0.266

Table 3: Diffuser is set different angle

When the diffuser is set different angle, than I see the velocity is increased a little. The performance of aerofoil is batter 15˚ attack angle.

Figure 5: Flexible diffuser



Graph 3: Velocity profile

3.3 Object is rotted different angle but system is set basic design.

The purpose of this test is, when the diffuser is set basic design, and objective is rotted different angles, than what in the changes Lift & Drag forces and boundary layer growth negative and positive point.

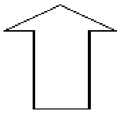
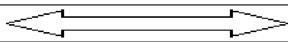
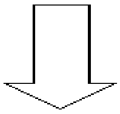
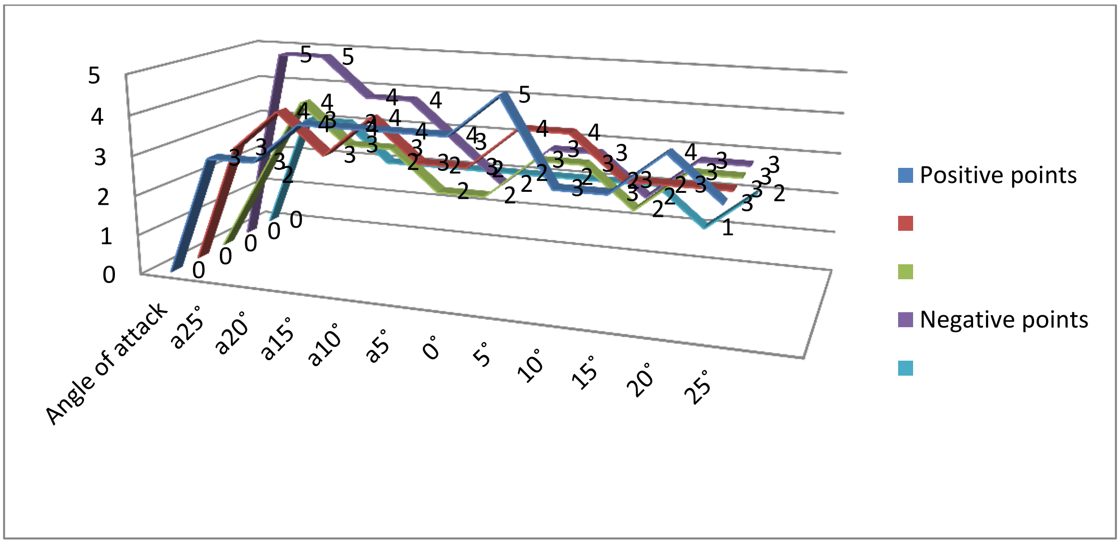
S.No.	Angle of attack	Manometer Readings (mm)					Position of object
		P-1	P-2	P-3	N-1	N-2	
1	25°	3	3	2	5	3	
2	20°	3	4	4	5	3	
3	15°	4	3	3	4	2	
4	10°	4	4	3	4	2	
5	5°	4	3	2	3	2	
6	0°	4	3	2	2	2	
7	5°	5	4	3	3	2	
8	10°	3	4	3	3	2	
9	15°	3	3	2	2	2	
10	20°	4	3	3	3	1	
11	25°	3	3	3	3	2	

Table 4: Object moved different angle

In this test we find the both side readings upward and downward. In upward reading the performance of aerofoil is batter 15˚ attack angle. And downward reading the performance of aerofoil is batter 15˚ & 20˚ attack angle.



Graph 4: Object moved different angle

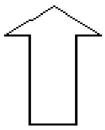
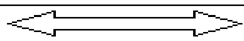
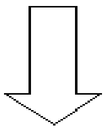
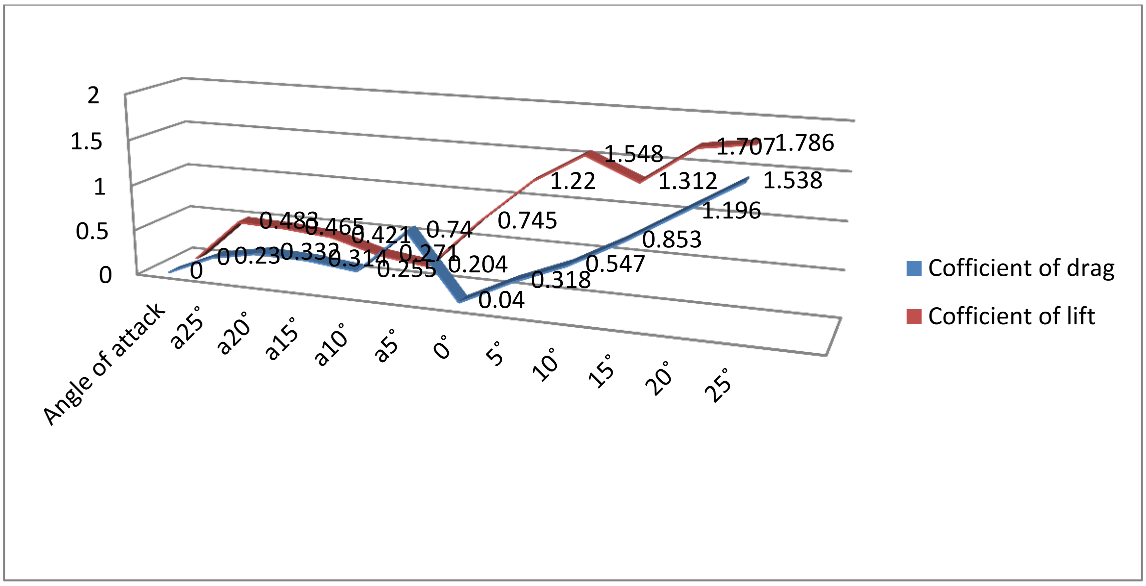
S. No.	Angle of attack	Drag force	CD	Lift force	CL	Position of object
1	25°	1.75	0.23	2.41	0.483	
2	20°	1.66	0.332	2.326	0.465	
3	15°	1.571	0.314	2.103	0.421	
4	10°	1.275	0.255	1.354	0.271	
5	5°	0.37	0.074	1.02	0.204	
6	0°	0.20	0.04	3.7278	0.745	
7	5°	1.589	0.318	6.072	1.22	
8	10°	2.736	0.547	7.740	1.548	
9	15°	4.267	0.853	6.562	1.312	
10	20°	5.98	1.196	8.535	1.707	
11	25°	7.69	1.538	8.93	1.786	

Table 5: Drag & lift forces



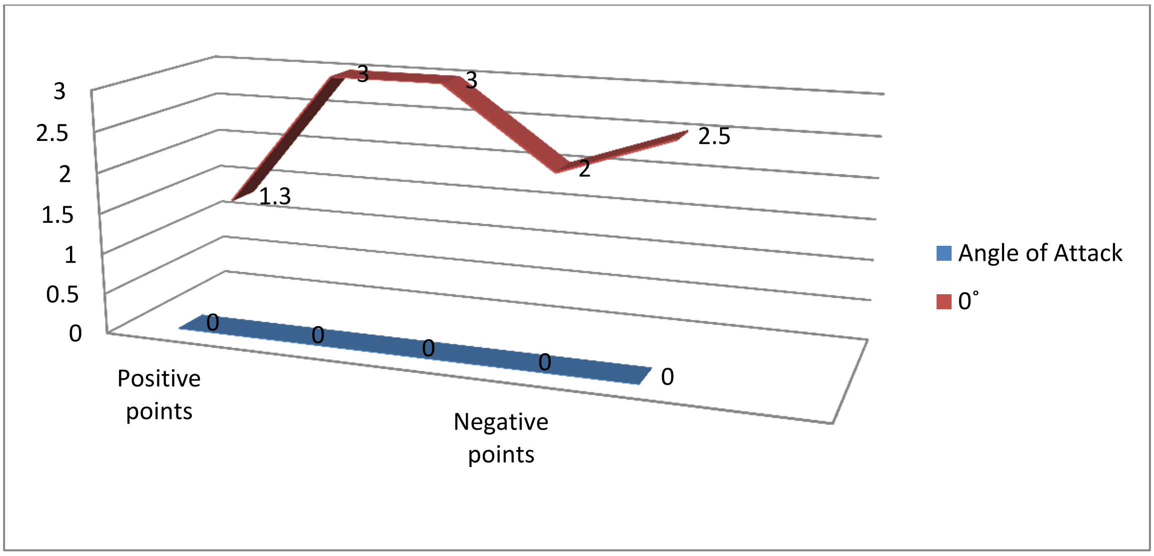
Graph 5: Drag & lift coefficient

3.4 The pressure of air on the vehicle that followed has not been made clear in earlier researches. That means the pressure of air that moved ahead will naturally hamper the speed of the vehicle that fallowed the first one. This important point is escaped in earlier researches. If the extra medium is generate front and behind the aerofoil, than what is the effect in the velocity and pressure.

Figure 6: half shaper medium in front of airfoil (horizontal)

Table 6: half shaper medium in front of airfoil (horizontal)

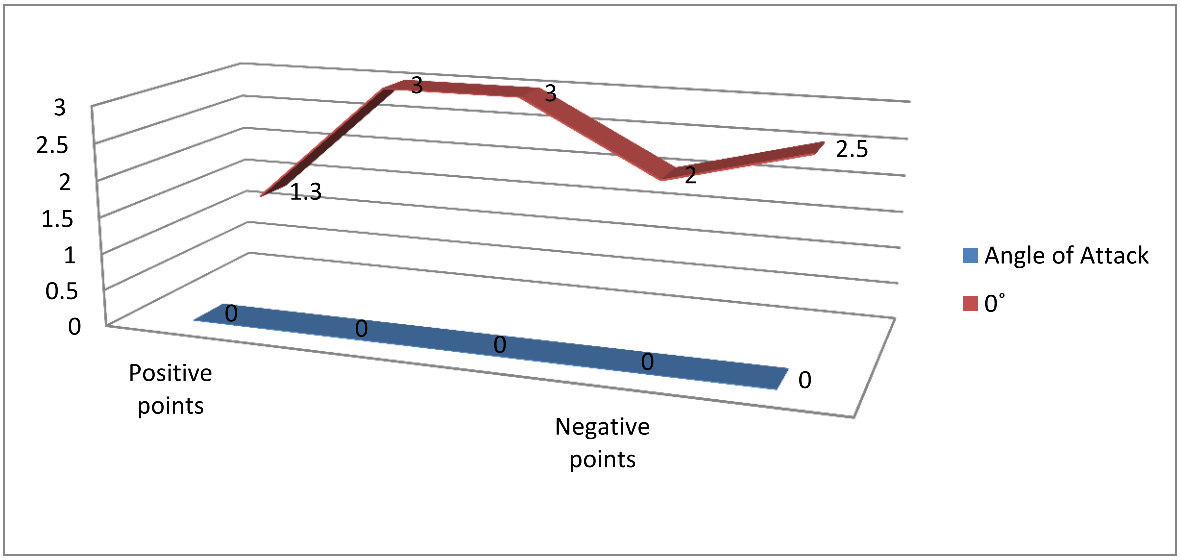
S. No.	Angle of attack	Manometer readings (mm)				
		P-1	P-2	P-3	N-1	N-2
1	0°	2	2.5	2.5	1.5	2



Graph 6: half shaper medium in front of airfoil (horizontal)

Table 7: half shaper medium in front of airfoil (vertical)

S. No.	Angle of attack	Manometer readings (mm)				
		P-1	P-2	P-3	N-1	N-2
1	0°	1.5	3	3	2	2.5



Graph 7: half shaper medium in front of airfoil (vertical)

In the last of the experiment following result I have found. The result is given bellow.

- When the vehicle is running condition than the pressure of air that moved ahead will naturally hamper the speed of the vehicle that fallowed the first one. The pressure is hampering little if the vehicle is streamlined. The pressure is hampering high if the vehicle is half sphere.

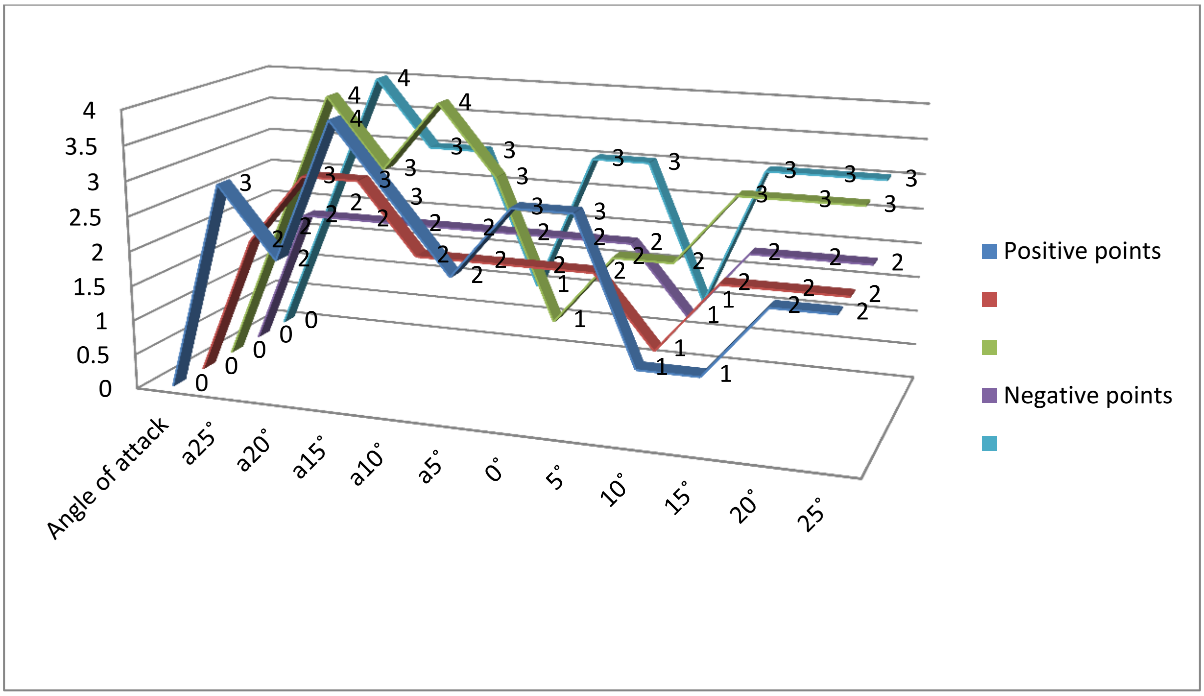
3.5 Object is rotted different angle but system is set basic design. The purpose of this test is, when the diffuser is set basic design, and objective is rotted different angles, than what is the boundary layer growth negative and positive point.

Figure 7: Supra car (side view)

- Length of supra car = 114.3 mm
- Height of supra car = 55.8 mm
- Arc of front (angle) = 13 mm
- Front width = 17.7 mm
- Rear width of selected area = 66.4 mm
- Scaling = 1mm = 10mm

Table 8: Object moved different angle

S.No.	Angle of attack	Manometer Readings (mm)					Position of object
		P-1	P-2	P-3	N-1	N-2	
1	25°	3	2	2	2	2	
2	20°	2	3	4	2	4	
3	15°	4	3	3	2	3	↑
4	10°	3	2	4	2	3	
5	5°	2	2	3	2	1	
6	0°	3	2	1	2	3	↔
7	5°	3	2	2	2	3	
8	10°	1	1	2	1	1	
9	15°	1	2	3	2	3	↓
10	20°	2	2	3	2	3	
11	25°	2	2	3	2	3	



Graph 8: Object moved different angle

In this test we find the both side readings upward and downward. In upward reading the performance of aerofoil is batter 15˚ attack angle. And downward reading the performance of aerofoil is batter 15˚ & 20˚ attack angle

3.6 The object – Supra car is set opposite direction in the testing section. And find the effect different position and presser losses also.

The prepuce of this test is, if each body is streamline shaped, than the velocity and pressure effect is what? If each is not design streamlined shaped, than the velocity and pressure effect is what? It is a comparison of both, who is batter? My prepuce is to create the good design for batter performance heavy duty vehicle.

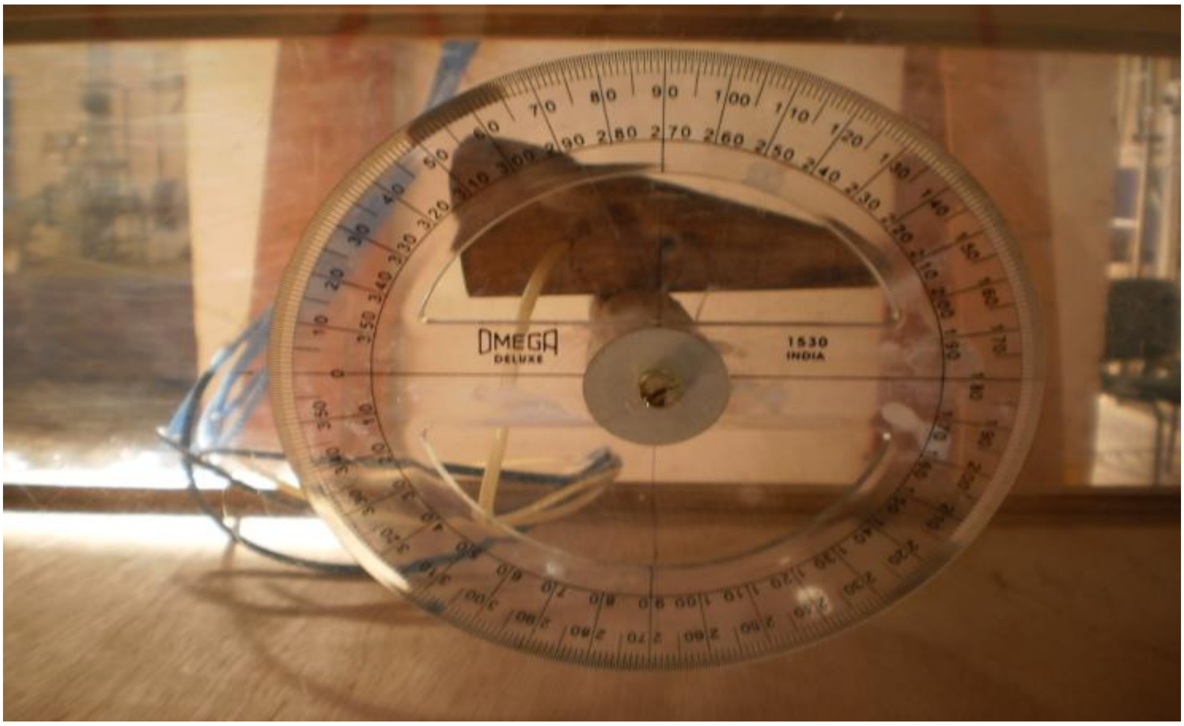
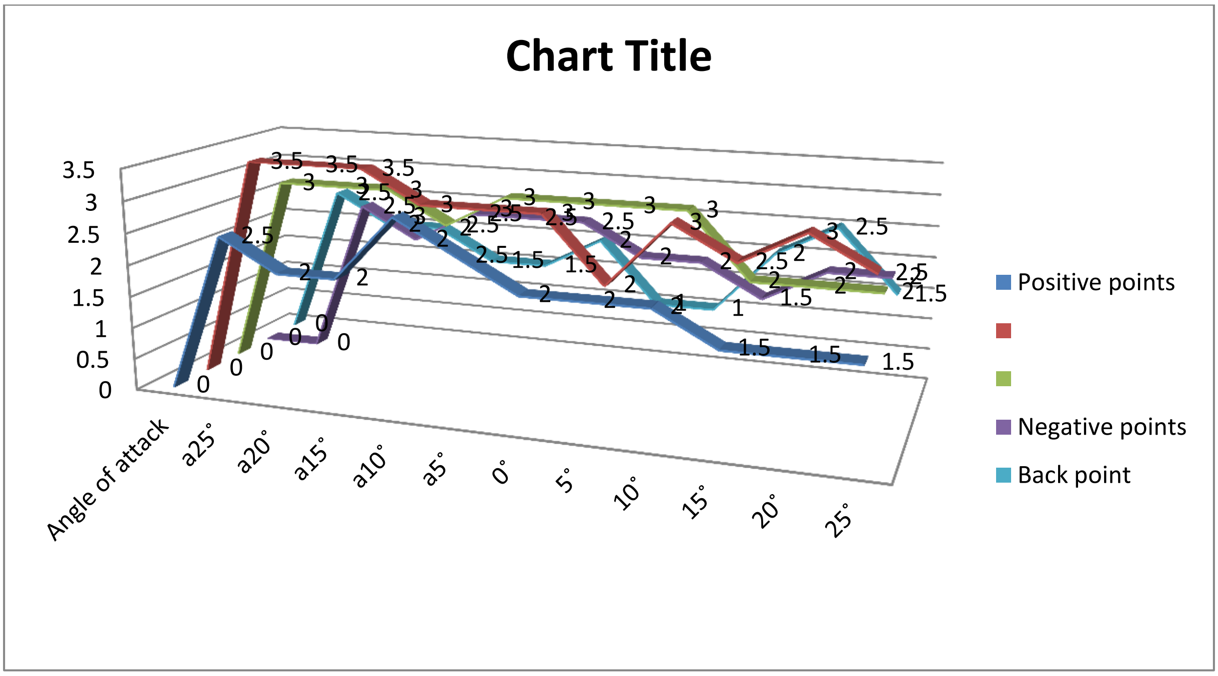


Figure 8: Back pressure analysis

Table 9: Back pressure analysis

S.No.	Angle of attack	Manometer Readings (mm)					Position of object
		P-1	P-2	P-3	N-1	B-2	
1	25°	2.5	3.5	3	2.5	2.5	
2	20°	2	3.5	3	2.5	2	
3	15°	2	3.5	3	2	2	
4	10°	3	3	2.5	2.5	1.5	
5	5°	2.5	3	3	2.5	1.5	
6	0°	2	3	3	2.5	2	
7	5°	2	2	3	2	1	
8	10°	2	3	3	2	1	
9	15°	1.5	2.5	2	1.5	2	
10	20°	1.5	3	2	2	2.5	
11	25°	1.5	2.5	2	2	1.5	



Graph 9: Back pressure analysis

The result is, if we fallow the streamlined design rule then each vehicles is performed batter. The velocity of vehicles will be improved.

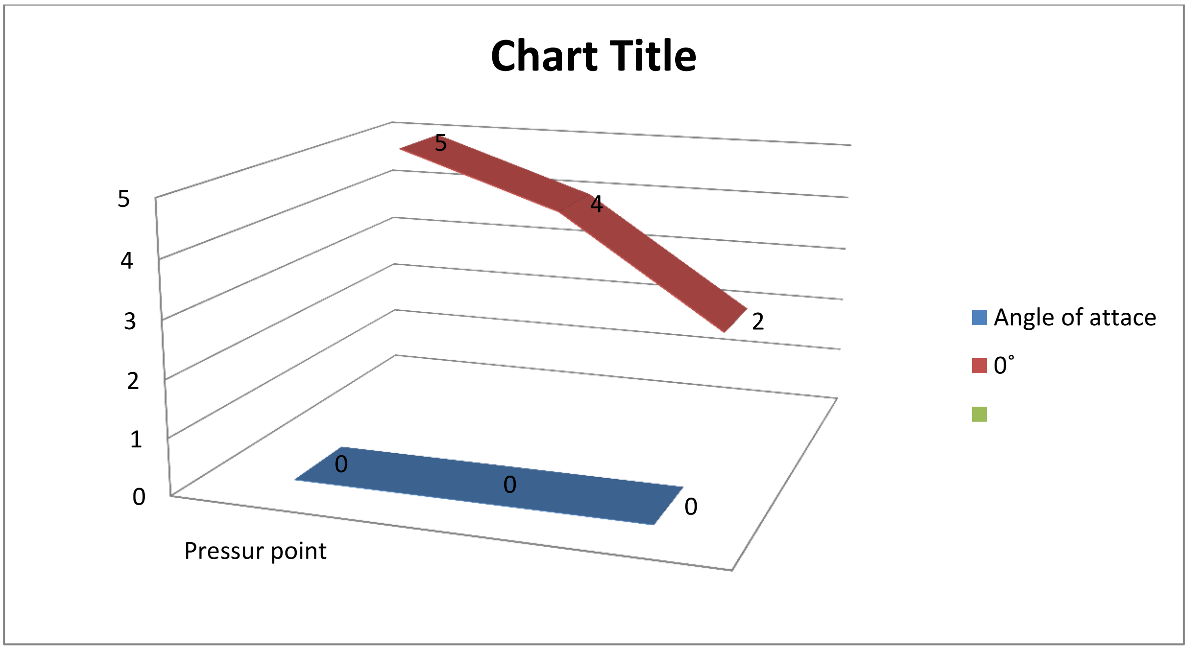
3.7 Condition – what is the effect of pressure/velocity of air on different angle of tyer.

- Scaling of tyer = 1mm = 10 mm

Figure 9: Testing pressure point of tyer

S. No.	Angle of attack	Manometer readings (mm)		
		P-1	P-2	P-3
1	0°	5	4	2

Table 10: Testing pressure point of tyer



Graph 10: Testing pressure point of tyer

The result is, when the tyer is moving condition than the pressure is different each angle of attack. In the research I marked three points. One is 0˚, 90˚, 180˚. In each point pressure is different. It is shown in the chart 5.5. in the tyer there no negative pressure.

4. CONCLUSION

Figure 10: End of experiment – result discursion

My research topic is design, construction, and testing open circuit low speed wind tunnel. In the research my effort is to fulfill all areas. After the testing objects I have note all readings carefully. One point I have noticed, if we change the setting diffuser, upward and downward, than in upward position the pressure is increased and the negative point is descries. If we set the diffuser downward position then the pressure is descries and the negative point/pressure is increased. The performance of the airfoil is batter 15˚ angle of attack.

When the diffuser is set different angle, than I see the velocity is increased a little. The performance of aerofoil is batter 15˚ attack angle again. The pressure of air on the vehicle that followed has not been made clear in earlier researches. That means the pressure of air that moved ahead will naturally hamper the speed of the vehicle that fallowed the first one. This important point is escaped in earlier researches. If the extra medium is generate front and behind the aerofoil, than what is the effect in the velocity and pressure.

So when the vehicle is running condition than the pressure of air that moved ahead will naturally hamper the speed of the vehicle that fallowed the first one. The pressure is hampering little if the vehicle is streamlined. The pressure is hampering high if the vehicle is half sphere. The prepuce of this test is, if each body is streamline shaped, than the velocity and pressure effect is what? If each is not design streamlined shaped, than the velocity and pressure effect is what?

It is a comparison of both, who is batter? My prepuce is to create the good design for batter performance heavy duty vehicle. The result is, if we fallow the streamlined design rule then each vehicles is performed batter. The velocity of vehicles will be improved. The important part of any vehicle is tyer. When the tyer is moving condition than the pressure is different each angle of attack. In the research I marked three points. One is 0˚, 90˚, 180˚. In each point pressure is different. It is shown in the chart 5.5. in the tyer there no negative pressure. Than the final result is my design performance is good. I have reached my CD 0.04. It is a good symbol for me for future researches. The cost of wind tunnel is less.

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