# Fabrication of Subsonic Open Channel Wind Tunnel and Analysis

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***Abstract*- The main aim of this research is to develop a miniature wind tunnel small scale and low cost that would experimentally validate a series of analytical models developed for academic research. The designed and modeled wind tunnel has constant flutter speed as was feasible, in order to permit it to be tested to the point of instability within the operating limits of the current facility.**

**Index Terms- Subsonic open wind tunnel, CAD drawings, Fabrication, Wind tunnel components.**

## I. INTRODUCTION

The low speed wind tunnel is used to flow inside the test chamber and helped to monitor the overall performances. The main objective of the this research is the flow performance of wind tunnel, how does air flow controlled in the test chamber and quality parameters. The performed experiments results are helped to solving aerodynamic problems [1]. In this contemporary world development depends on computer numerical simulations towards new technologies but the use of wind tuneel solving problems from basic to complex is still needed to the aerodynamic sector [2,3]. In general computers produce quantitative data but wind tunnel provide clear flow visuvalization in practical way. The first-generation model consisted of a hollow plastic wing rapid-prototyped from ABS plastic using 3D printing technology. The test section is around 1/2 feet X 1/2 feet with test section velocity of around 15- 20 m/s/. The lift drag component will be integrated within the wind tunnel to calculate the lift and drag forces. This paper deals with the design of an open type wind tunnel to have minimum construction cost. The test chamber dimension depends on the type of test to be performed and the size of the model to be tested [4.5].

## II. WIND TUNNEL COMPONENTS

### A. Contraction cone and test section

The figure 1 shows that, the contraction cone and 3D printed object inside the test section. The first part of the wind tunnel is contraction cone. It is decreasing the input velocity of the air from the compressor and increases the pressure [6,7]. The objective of contraction cone is the increase the velocity of the inflow and thereby reducing the pressure. The design of the contraction cone is the difficult part of the wind tunnel.

Figure 1. Contraction cone and test section.

Table 1. Design parameters of contraction cone.

| Variables | Values (in mm) |
|---|---|
| Inlet area | 442 × 442 |
| Outlet area | 161× 141 |
| Contraction cone length | 430 |
| Settling chamber length | 100 |

The table 1 shows that the design parameters of the contraction cone. There are multiple aspects in a contraction cone like, settling chamber length, curve

profile, the area ratio, etc. The high - pressure air flown over the test section.
Table 2 shows that, design parameters of test section. In general, the test section is the important part of any wind tunnel. Basically there are many parts in a wind tunnel and the test section influences the design and calculations of other components [8.9]. The 3D printed test specimen is placed in the test section.

Table 2. Design parameters of test section.

| Variable | Value (mm) |
|---|---|
| Length | 222 |
| Breadth | 161 |
| Height | 141 |

B. Diffuser

The table 3 shows that, the length and other design calculations of the diffuser. The diffuser is the last component at the rear end of the wind tunnel. It is a multi-section body which changes its shape from a rectangle to a circular outlet.

Table 3. the design parameters of diffuser.

| Variables | Values (in mm) |
|---|---|
| Diffuser length | 700 |
| Inlet area | 161*141 |
| Area ratio= (outlet area/inlet area) | 2 |

C. Test object

A 3D component of sphere of 8.5 cm diameter is made using a modern 3D printer Pursa. The component is made with a handle to be supported by Lift-Drag component. The figure 2 shows that, the CAD model of test specimen. The sphere CAD model is first made using SolidWorks and then analyzed using the same for a given velocity determined by the motor used in the compressor. Before giving the simulation CAD model of the test object is given below. A simple model for test subject is chosen to facilitate the installation and its construction. A simple 3D model is easy to be made using 3D printer.

Flow analysis over a sphere is a classic example in experimental fluid dynamics. Due to its simplicity and a benchmark for many applications in the engineering sector, sphere of diameter less than 10 cm is chosen for this project. A synthetic plastic material is used in 3D printer to provide Fusion Bonding of the sphere.

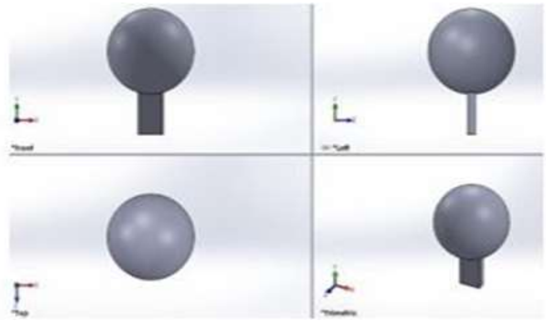

Figure 2. CAD model of test specimen.

D. Subsonic open channel wind tunnel cad model

Table 4. Design parameters of wind tunnel

| Variable | Values (in mm) |
|---|---|
| Overall length | 1354 |
| Area ratio | 0.349 |

The figure 3 shows that, the overall design of CAD model of wind tunnel. The complete CAD model of the open flow subsonic wind tunnel which is designe given in this section. One of the noticeable facts about this wind tunnel is that the desired flow velocity is achieved in test section with less pressure drop. The Analysis report will have more details regarding the flow and only the design parameters will be considered in this section. The table 4 shows that, design parameters of wind tunnel.

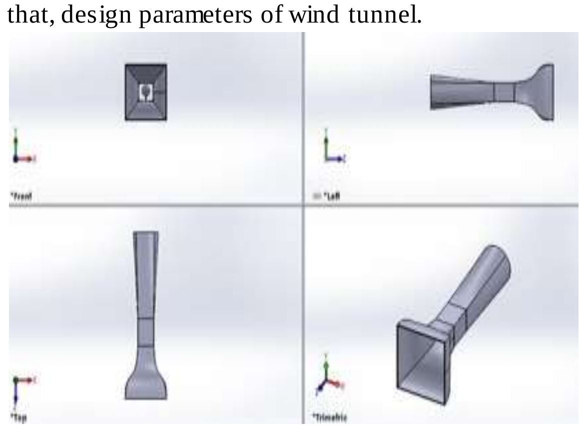

Figure 3. The overall CAD model of wind tunnel.

## III. CALCULATIONS

Before the flow analysis takes place, the calculation required for the test section velocity is to be made. Since it is an open-circuit, subsonic wind tunnel, an average of 0.25 M is taken. The calculation is done as following.

The first experiment done in the wind tunnel is the calculation of average velocity in the test section.

This is the first most experiment needed to be done before testing the main test subject. For this, pitot static tube is used. Pitot static tube is an apparatus which tell a difference is pressure relatively and from its velocity can be determined.

The formula to calculate the velocity using pitot static tube is,

$$\mathbf{V} = \frac{\sqrt{2\delta H_g\, gh(SGH_g}}{\delta_{air}}$$

Where,

$V$ – Velocity of the fluid

$\rho_{Hg}$ – Density of Mercury

$\rho_{air}$ – Density of Air

$g$ – Acceleration due to gravity

$h$ - Difference in pitot static tube

$SG_{Hg}$ – Specific Gravity of Mercury

The value of ‘h’ is experimentally found and is pictured in the following tabular column,

The average of h is taken as, $\boldsymbol{h} = \frac{3+4}{2}$

$= 3.5$ cm

Substituting the known values in the above equation, we get,

$$\mathbf{V} = 2 \times 1000 \times 9.81 \times 35 \times \frac{13.6}{1.23} \times \frac{1}{1000}$$

$$\mathbf{V} = 87.1 \text{ m/s}$$

At atmospheric temperature of 20° C, the speed of sound is 343 m/s. Therefore, the acquired Mach number is 0.254 which is expected as subsonic. Then this value is taken into analysis and the result is produced.

## IV. ANALYSIS

The figure 4 shows that, the flow analysis of wind tunnel. The model is designed in solid works and presented. The flow analysis through wind tunnel is executed using calculated measurement values. The flow simulations have been done using computer simulation software.

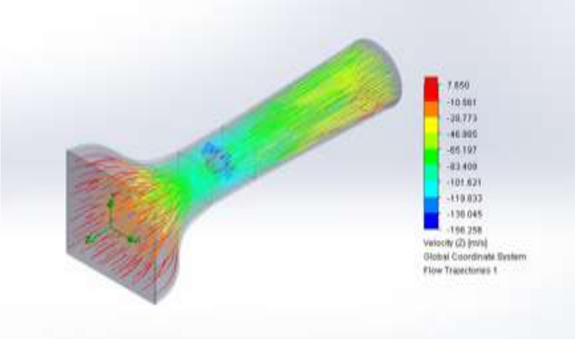


Figure 4. Overall flow analyses over test sample

The figure 5 shows that, flow analysis over test object. The flow analysis includes the increase in the flow towards the test sample and there is a significant change around the sphere.

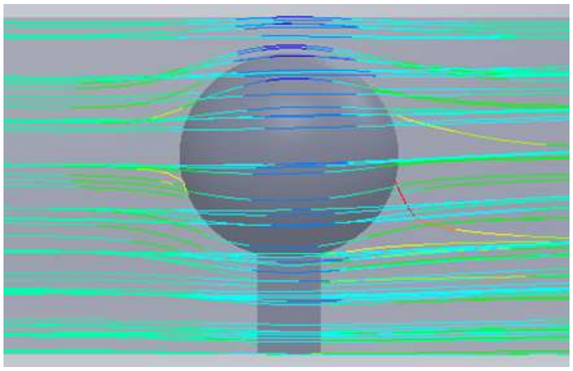

Figure 5. Side view of the test sample.

The figure 6 shows that, the isometric view of the flow over test object. The flow visualization have been presented clearly.

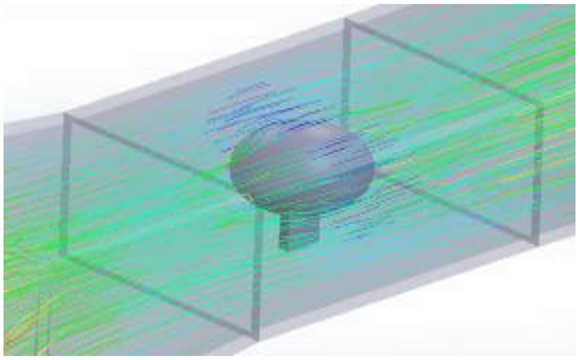

Figure 6. Isometric view of flow over test sample.

## V. CONCLUSION

The design and fabrication of low-speed open channel wind tunnel has been done. The ultimate goal of this research is to provide wind tunnel for small scale analysis for academic research. The design parameters of the each component such as contraction cone, test section, diffuser and test object is calculated and presented clearly.

The CAD model for each section is designed and analyzed using computer simulation. The design parameters for the each section of component have been done. The overall flow analysis carried out over test sample. The different views of the test object and flow characteristics have been presented clearly.

This research concluded that, the designed and fabricated wind tunnel has constant flutter speed is feasible, in order to permit it to be tested to the point of instability within the operating limits of the current facility. This analysis is satisfied both theoretically and practically.

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