A Review Paper on Design Development & Fabrication of Wind Tunnel

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Abstract— In the world, which is continuously progressing with the large amount of cost saving and where most of the aircrafts, automobiles are designed using software's and then they are analysed for preliminary results. In the real time designs however need to be verified and examined so that the budget constraint can be done on the appropriate scale. Wind Tunnels are used to get aerodynamic properties and response of the aircraft under different condition and orientation. It is a tubular like structure or apparatus with a varying cross-section area with air flowing in it. Wind Tunnels offer an efficient tool for finding the data that is associated with flow over scaled or full-scale model very fast. Therefore, we are going to see the fundamentals of the low speed wind tunnel design. The wind tunnel design in this case is capable of generating laminar flow. In test section, to analyse the internal flow manual analysis was used. This paper along with analysis focuses on different wind tunnel parameters like the shape of wind tunnel, size and orientation, air delivery, inlet outlet dimensions and length of the wind tunnel. Because of the ability of wind tunnel to combine quantitative as well as visualization data, it is a crucial instrument in designing and analysing any component that uses fluid dynamics.

Key words: Wind Tunnel, Exhaust Fan, Wind Energy

I. INTRODUCTION

A wind tunnel is a device in which a jet of air or any other suitable fluid of uniform properties across the cross section is produced. A wind tunnel apparatus is similar like as a nozzle which reduces high pressure to low pressure.

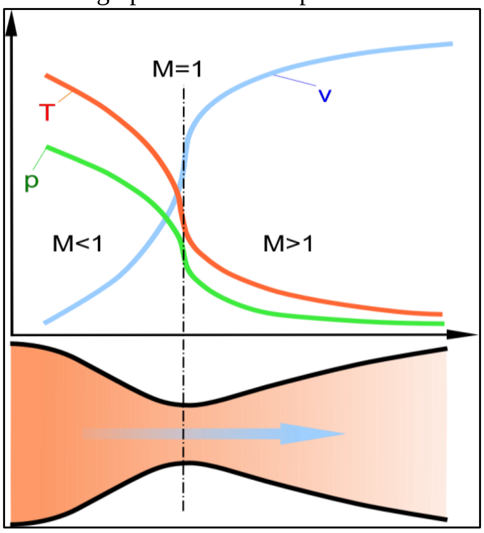

Fig. 1: Nozzle

A wind tunnel simulates the condition of aircraft in flight by causing a high-speed stream of air to flow past the model of the aircraft or automobile being tested. The wind tunnels are classified based on construction as viz. Open Circuit Wind Tunnel and Closed-Circuit Wind Tunnel.

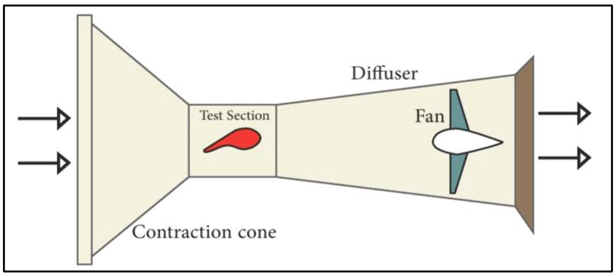

Fig. 2: Open Circuit Wind Tunnel

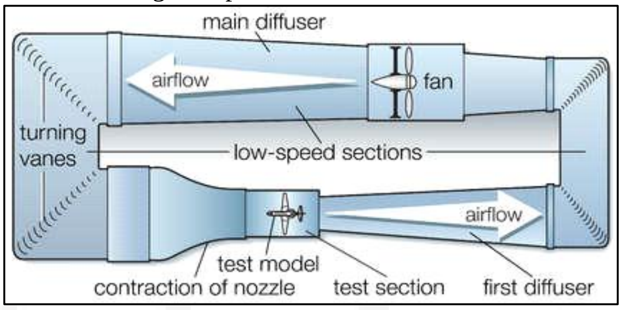

Fig. 3: Closed Circuit Wind Tunnel

The wind tunnels are classified based on flow speed as:

1) Subsonic or Low-Speed Wind Tunnels: Subsonic or low-speed wind-tunnels are the most common type and the wind tunnel described in this paper is of this type.
2) Transonic Wind Tunnels: Transonic wind-tunnels are common in the aircraft industry since most commercial aircraft operate in this regime.
3) Supersonic Wind Tunnels: Supersonic wind-tunnels can be used to investigate the behaviour of jet engines and military aircraft.
4) Hypersonic Wind Tunnels: Hypersonic wind-tunnels find their applications in rockets and space vehicles.

A. *Components of the Wind Tunnel*

The wind tunnel consists of close tubular passage with an object under test mounted in the middle. A powerful fan system consisting of one or multiple fans moves air past the object. All the wind tunnels are generally comprised of a driving unit, a settling chamber, an acceleration duct (either contraction or nozzle), the test section and the diffuser. The driving unit consists of fan, blower or a compressor generally driven by an electric motor.

Following are the components of the wind tunnel:

1) *Contraction Section*

Contraction section is located in front of test section and is use to increase air speed in test section as well as to moderate the inconsistency in the uniformity of flow. Large contraction ratios and short contraction lengths are generally more desirable as they reduce the power loss across the honeycomb structure and the thickness of boundary layers.

2) *Honeycomb Structure*

The honeycomb structure is often columnar and hexagonal in shape. Honeycomb structure is situated in between contraction cone and test section and is used to reduce non-uniformity in the flow.

3) Test Section

Test section is a transparent section. It is a chamber in which test object is placed and observations and readings are made on it. The shape and size of the test section depends on testing requirements. The test section should be long enough that flow disturbance resulting from contraction should be dampened out before reaching the object. However, care should be taken not to make this too large because it can cause boundary layer separation in diffuser section and can ultimately lead to power loss.

4) Diffuser Section

Diffuser is a section placed at the exit of the test section through which the air exists the tunnel. It is gradually expands along its length, allowing fluid pressure to increases up to atmospheric pressure while decreasing fluid velocity. Angle slightly greater than 5 degree causes increase in pressure which in turn leads to boundary layer separation and unsteadiness.

5) Exhaust Fan

The exhaust fan is situated in diffuser section as per requirement. A powerful exhaust fan system consisting of one or multiple fans used to move air past the object. The driving unit consists of fan driven by an electric motor. Also, it has a regulator to control the speed of the exhaust fan.

Wind tunnel testing can be applied to automobiles to determine ways to reduce the power required to move the vehicle on roadways at a given speed. In these studies, the interaction between the road and the vehicle plays the significant role and this interaction must be taken into consideration when interpreting the test results. Wind tunnels for wind turbine testing and mechanical aspects are very important. However, many issues such as exhaust fan selection, anemometer selection and their placement involve electrical and instrumentation engineering. This paper has been organized to cover up various applications, measurements aspects.

II. Literature Survey

In 1871, ‘’Francis Herbert Wenhann’’; a council member of aeronautical society of Great Britain made the invention, design and operation of the first enclosed wind tunnel. Later on, wind tunnel testing was applied to automobiles, to determine not only aerodynamic forces but also to the ways to reduce energy required to move the vehicle on roads. One of the largest wind tunnel in the world was built at the Washington Navy Yard in 1916 with an inlet of 11 feet in diameter and the discharge part of 7 feet in diameter.

Osborne Reynolds of the University of Manchester (1853) demonstrated the air flow pattern over a scale model will remain the same for the full-scale vehicle if the certain flow parameter were the same in both the cases. This factor is now known as Reynolds number which is the basic parameter in the description of all fluid flow situations, like the shape of flow patterns, the onset of turbulence and the ease of heat transfer. This forms the central scientific justification for the use of models in wind tunnels to simulate real life phenomena. But there are limitations on conditions in which dynamic similarity is based on the Reynolds number alone.

Pankhurst and Holder (1952) has described the concept of relative motion, "It has been shown that the flow pattern around the body depends on the relative motion and is the same whether the body is moving through a fluid at rest or is in stationary in a moving stream "This relative motion statement was the backbone of wind tunnel testing as it states that in order to test that the aerodynamic attributes of the model, the model does not have the air The air may be moved around the model. Since the test could be controlled using a wind tunnel, test engineers could increase and transition the design to simulate the yaw, climb, and diving conditions.

Roberts (1961) noted that "the small wind tunnel is expected to play an important part in relieving the load on the big wind tunnels and the completion of expediting or otherwise lower priority investigation". These low priority investigations have now become much more important in the post war era, where power generation is a much big concern than that time. Scene many big tunnels have been forced to shut down due to overwhelming operating costs and maintenance fees, full scale testing is being eliminated in the form of computer testing and design.

III. Conclusion

From above literature survey we conclude that there are very few wind tunnels in some developed countries. By a large they are of smaller/medium size and hence not suitable for automobile/energy sector trials i.e. automobile/aerodynamic studies and wind energy testing. This the main hurdle in research and development of these sectors. Research in these areas cannot be done at college level as such facilities are not available with educational institute. Thus, entire research work in these areas is done by industry. Wind tunnel and test models aren’t cheap to build, that’s why more and more organisations are deactivating their wind tunnels and shifting to computer modelling. However physical wind tunnels are used to retest the results of the computer modelling. Thus, this paper has presented the classification of basics of wind tunnel. Need of, its construction, applications and associated parameters have been presented.

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