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Research Article

Low Speed Wind Tunnel Applications-A Review

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Abstract

Wind tunnels are popularly used in testing of applications such as aerodynamics, automobiles, architects, submarine etc. A low speed wind tunnels and its type are present in this .This paper focuses on the wind tunnels and its computational solving approaches. Based on this study, the application of a wind tunnel leading to the quantative predictions have been a combination of theory and experiment. Low speed wind tunnels are about mach no =0.4, 134 m/s this paper gives the idea about various parameters and methods that used for calculation of pressure and temperature and computational methods. This review concludes that, the use of low speed wind tunnel can give the idea for improving the streamline shape of the model and by using scale model cost will be saved.

Keywords: *Wind tunnel, mach no, CFD, Reynolds no*

Introduction

Currently, The world is facing many environmental problems every day aero planes and automobile consumes lots of oil or fuel, but by improving the shapes of aero planes and automobile we can improve the efficiency and save the fuel, by the help of wind tunnel we can predict the behavior of forces by using scale model instead of using actual model and can save testing cost. It is primary tool for experimental aerodynamics and its uses save both money and lives. There are two types of wind tunnels and two basic test-section configurations. Two basic types are open circuit and closed circuit. Two basic test configurations are open test sections and closed test sections. The wind tunnel was invented by Frank Wenham, who invented wind tunnel in 1871.the basic wind tunnel is shown in Fig1.

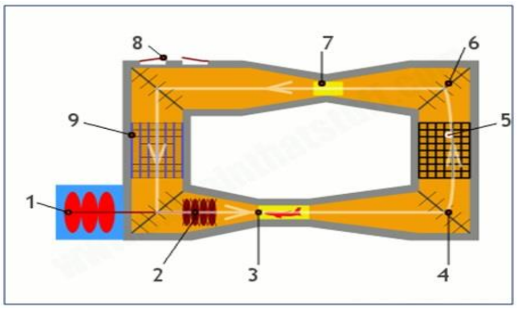

Fig1. Schematic wind tunnel

A wind tunnel is a research tool developed to assist with studying the effects of air moving over or around solid objects. The speed and flow of air in a wind tunnel can be measured in any of several ways. For instance, threads can be attached to the surface of study objects to detect flow direction and relative speed of air flow. Alternatively, dye or smoke can be injected upstream into the air stream and the streamlines followed by the dye particles can be photographed as the experiment proceeds. Also, Pitot tube probes can be inserted in the air flow to measure static and dynamic air pressure.

Drive motors: These are giant electric motor that spin fan.
Compressors: The fan that produce the high speed.
Supersonic, high speed test section: The model airplane is placed in here.

Vanes: These are airfoils position in corner to turn the air through 90° without losing energy.

Acoustic muffler: Wind tunnels are noisy places & mufflers help reduce the noise and more accurately simulate realistic air flow.
Vanes: Subsonic, low-speed test section: There's a smaller test chamber round the other side where the air moves a bit slower.

Access doors: The researcher to get in the tunnel.
Air dryer: This section removes moisture from the air flow

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Wind tunnels are popularly used in testing of applications such as ground vehicles, aerodynamics, architects, submarine etc. all these applications are explained in fallows.

Ground Vehicle Applications

There has many low speed wind tunnel are constructed for testing of ground vehicle in design decision of buses, motorcycle, trucks and racing cars of all types

Most of the wind tunnel experiment results obtained for force and moment acting on a test vehicle in controlled or repeatable environment. Force and moment measurement are important for all ground vehicles. For some principle interest is on drag force because of its reflection on energy requirement. Drag is often the component that receives the greatest attention as it has dominant effect on fuel consumption at a given speed and on the top speed attainable. The lift force is of extreme importance in determining controllability for performance cars and race cars, becoming more critical as the speed increases. The Figure 2 shows the importance of drag over shape of vehicle

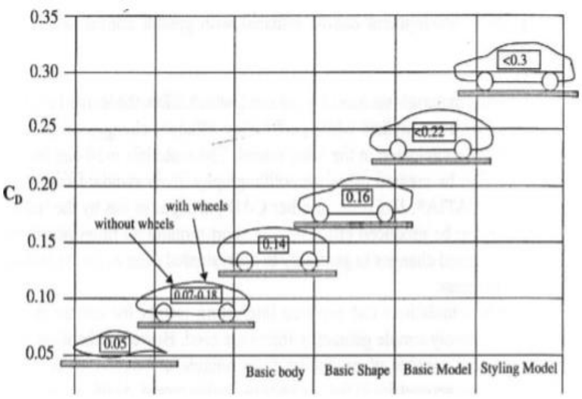

Fig.2 A schematic: shape optimization process (J._B._Barlow,_W._H._Rae,_Jr,_A._Pope)

Careful study of the cooling system performance is an important part of development commonly done in the wind tunnel. In cases of buses and trains the propulsion units are usually much bigger and hence the heat source is increased. The concern then becomes not only that heat be dissipated but also that heat be kept away from the passenger compartment.

Marine Vehicles Applications

The experimental procedure is fallow the same logic as those for purely atmosphere. Most marine vehicle operates at the interface of the air and water. Consequently, wind tunnel experiment for marine vehicles examining phenomena both above and below the surface. Wind acting on the top side and superstructures of the ships can generate considerable loads that frequently must be accounted for design process. When the ship is intact, these forces affect the sizing of propulsion machinery and maneuvering thrusters and mooring and berthing arrangements.

All the ships require air for combustion and releases exhaust gases into the atmosphere. These gases are high in temperature and contain corrosive combustion by products. Such as sulfuric acid, that need to be dispersed clear off. These gases can affect the operation of the ships. Wind tunnel experiments are frequently used to investigate these issues. A related problem is a wind invasion on the external passenger space of ships and recreational yachts. Example, outdoor recreational areas on the ships. These spaces are usually protected from excessive wind by carefully shaped superstructure, railings, and windbreaks surrounding the area affected.

The marine wind tunnel operations has to be carried out in following manner as shown in figure 3. The non-distorted physical model is constructed according to a linear length scale of 1:150. The inertial and gravity forces are more important than other properties, such as surface tension and viscosity. Therefore, modeling is performed according to the Froude similarity law, without distortion of scale

Offshore Technology Research Center (USA) .

Fig.2 Marine wind tunnel using fans (Lazro Redonodo,2016)

Architecture engineering Applications

The development of new light-weight materials and advanced construction technique in recent years has resulted in the emergence of many super tall buildings, generally wind sensitive structures (Jun Yi et al, 2015). For these high rise structures, wind loads generally control the structural design, resulting in a greater emphasis on understanding on understanding the structural behavior of super tall buildings under strong wind actions, in particular in typhoon or hurricane prone regions. Therefore, it is necessary to conduct comprehensive investigation of the wind effects on super tall buildings.

An experimental investigation was carried out by Jun Yi (2015) to determine wind forces on a super tall building. In this study, wind tunnel experiment using SMPSS (synchronous multi pressure sensing system) for pressure measurement and HFBB (high frequency force balance) for global force measurement on two models of the super tall building were conducted. The models were 1:400 scaled reproduction of the external surface of the super tall building. The above given two model is shown in figure 4 .

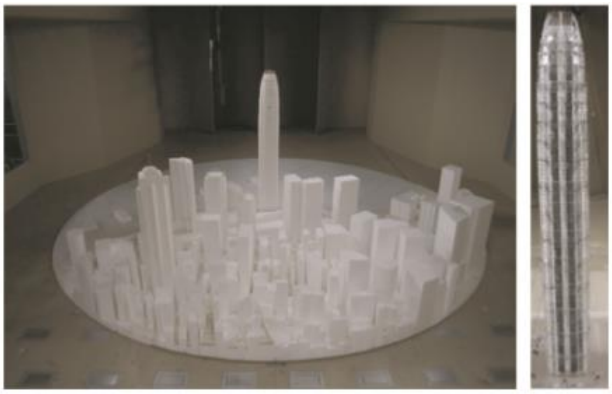

Fig.3 (A)Model for HFFB test, (B)Model for SMPSS test(Jun Yi, 2015)

Following results were get in super tall building from the case study by Jun Yi (2015).

The mean global force coefficient decreases as thr ground roughness increased. The interference effects from the surrounding buildings were significantly dependent on the incident on the wind direction in which mainly led to a reduction in the mean wind loads when the target building was sheltered wind direction, which lead to reduction in the mean loads when the target building was sheltered by upwind buildings.

Aerodynamics Applications

Wind tunnel is a basic experimental facility, in which a variety of aerodynamic research can be conducted by measuring force acted on the test model, pressure distribution on the model surface, as well as by visualizing the flow around the mode The force measurement test is conventional and especially important for the aircraft and other vehicle design to predict their performance. An experimental investigation was carried out by H. J. Shim (2013) low speed wind tunnel test results of BWB-UCAV model. An unmanned combat air vehicle (UCAV) is a state of the art unmanned aerial vehicle (UAV) system. In this study, an experimental model (referred to as BWB-UCAV herein after) having the same platform as that of the UCAV 1303 was tested in a low speed wind tunnel to get various aerodynamic force and moment coefficients at various angles of attack and yaw angles which are often not available in a unified manner. To help understand flow structures, surface oil flow visualization and pressure sensitive paint (PSP) measurement were also made.

This experiment was conducted in the subsonic wind tunnel of the Korea Aerospace Research Institute(KARI) at free stream velocity of 50m/s. the test section of subsonic wind tunnel is 1.0 m wide, 0.75 m high and 2.0 m long. For force and moment measurements using internal balance, the signal conditioning extension for instrumentation of the National Instruments Corp. (NI-SCXI) was used. The model was tested at angles of attack ranging from -2° to 18° at an increment of 1° in pitch-pause mode for a given yaw angle. The yaw angle was varied from 0° to 20° at a 2° step. For the case of 0° yaw angle, the angle of attack was varied from -2° to 23°. Figure 5 schematically shows three-views of the BWB-UCAV model.

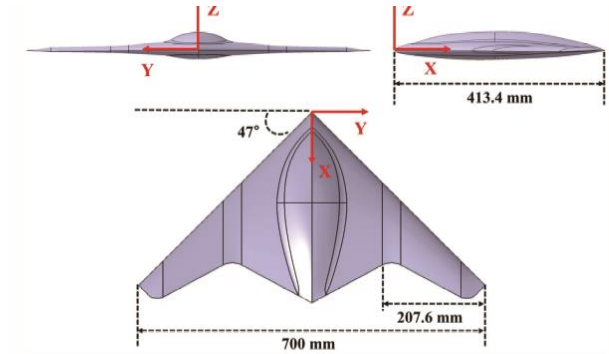

Fig.5 Three views of a BWB-UCAV model and coordinate system of internal balance schematic (H. J. Shim, 2013)

Pressure sensitive paints(PSP) measurement has been developed as an advanced measurement technique for surface pressure distribution. To elucidate some aerodynamic flow structure, PSP technique was applied in the present work for the surface pressure distribution of the model. for this, model was coated with binary paint. Figure 6 shows the PSP measurement system set up for present study model. for this, model was coated with binary paint. Figure 6 shows the PSP measurement system set up for present study.

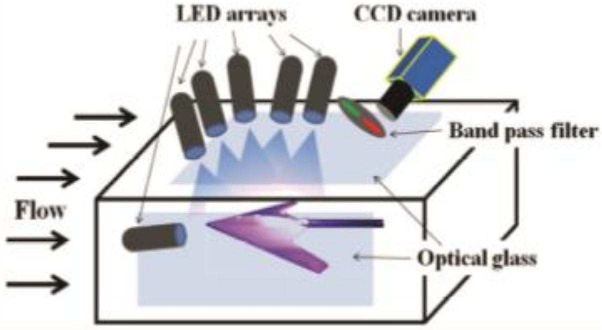

Fig.6 Pressure sensitive paint (PSP) measurement system (H. J. Shim, 2013)

Six lamp modules were installed to generate sufficient luminescent intensity. . A monochrome charge-coupled device (CCD) camera which was a PCO 2000 was used to acquire the luminescence intensity from the PSP. Two different optical filters were installed in front of the CCD camera to acquire sensitive images and reference images. The top and side wall of the test section was made of an optical glass to prevent refraction and reflection. This experiment results are discussed in follow,

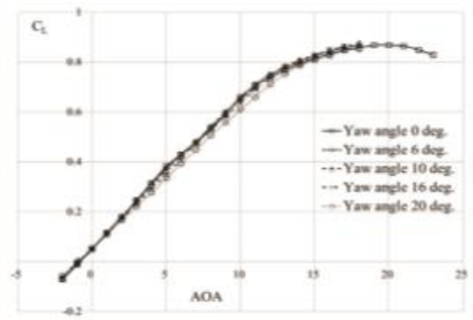

Fig.7 Variation of lift coefficient (H. J. Shim, 2013)

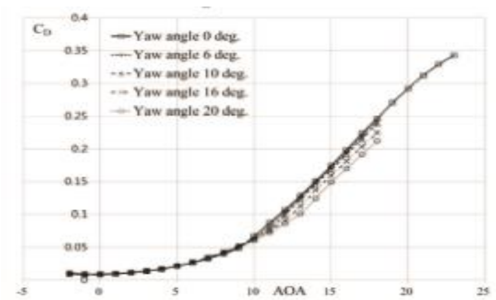

Fig.8 Variation of drag coefficients with various yaw angles (H. J. Shim, 2013)

Figure 7 shows the variation of the lift coefficient (C_L) with angle of attack and yaw angle. We see that there is very little yaw angle effect on the lift curve slope. In the case of 0° yaw angle, maximum lift coefficient (C_{Lmax}) is 0.868 at 20° angle of attack and zero lift angle of attack is about 0.75°.

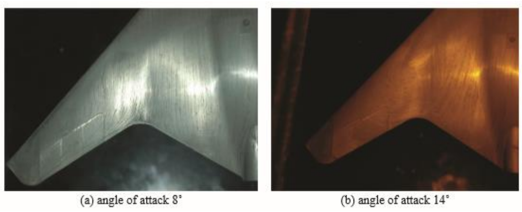

Fig.9 Oil flow visualization results (H. J. Shim, 2013)

Figure 8 shows the variation of drag coefficient (CD). The yaw angle effect on drag coefficient is seen to occur at angles of attack greater than 10°. Other graph also can be plotted. As mentioned earlier, oil flow visualization was also carried out at several angles of attack with zero yaw angle. Fig. 9 shows the results of oil flow visualization at 8° and 14° angles of attack, which may best be seen in electronic version. Oil streaks shown in the figure show clearly the occurrence of flow separation in the outboard region of the wing and the out flow phenomenon toward the wing tip in the trailing edge region

Conclusion

The review on the use of low speed wind tunnel applications shows that wind tunnels are very efficient for experimental calculation and flow visualization by using scale which can be easily predict the same effect as instead of using full scale model it saves both money as well as life. Low speed wind tunnels are applicable to many applications such as in marine applications, architectural applications but most of it is give the accurate result in aerodynamics applications

References

H.J. Shima, S.O. Parka (2011), Low-speed wind-tunnel test result of a BWB-UCAV model, 7th Asian-Pacific Conference on Aerospace Technology and Science, 7th APCATS

J.-P. Pinelli, C. Subramanium, M. Plamondon, (2004), Wind effect on emergency vehicles, Florida Institute of Technology, Melbourne, FL. USA

Jun Yi, Q.S. Li, (2015), Wind tunnel and full-scale study of wind effects on a super-tall building, Department of Architecture and Civil Engineering, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong.

Yan Li, Xingzhi Ding, Yankui Wang, (2009), Force Measurement System of a Low-Speed Wind Tunnel Wind, School of Aeronautic Science and Engineering, Beijing University of Aeronautics and Astronautics, Beijing 100191, China.