TEST Engineering & Management

January - February 2020
ISSN: 0193-4120 Page No. 3244 - 3247

Educational Wind Tunnel for the Sports Aerodynamics

G. Nallavan
Tamil Nadu Physical Education and Sports University, Chennai, India.
Nallavan47@gmail.com

Article Info
Volume 82
Page Number: 3244 - 3247
Publication Issue:
January-February 2020

Article History
Article Received*: 18 May 2019*
Revised*: 14 July 2019*
Accepted*: 22 December 2019*
Publication*: 20 January 2020*

Abstract:
Tamil Nadu Physical Education and Sports University [TNPESU] is India's first university exclusively for physical education and sports in India includes research and courses in Sports technology and science. The Sports Aerodynamics is basic and needed research in the development of Sports products and athlete performance. TNPESU had a Wind Tunnel Laboratory for the Sports science and technology students for education and research purposes. Wind tunnel designed with the objective of analyzing different sports ball, to find the three forces and moments, Pressure distribution and the velocity streamlines in static and rotation of the ball

Keywords: *Sports University, Wind Tunnel. Athletic Performance, Sports Aerodynamics, Sports Ball*

I. INTRODUCTION

The wind tunnel is a facility used for the aerodynamics study to know the motion of air and to calculate the force and moment acting on the body. For the sports aerodynamics research and coursework, the wind tunnel is the essential facility [1].

A wind tunnel is designed based on the application, the velocity of the air in the test section and pattern or quality of the flow in the test section [1]. In the Sports Aerodynamics research the most common models are balls, disc, frisbee, cars, bikes, apparels, cyclists, athletes and stadium mostly all are tested in low Speed subsonic and Atmospheric Boundary Layer [ABL] is generated for the Stadium[1,2].

The Sports Aerodynamics wind tunnel designed and developed based on the maximum speed in the test section, test section size based on the model size with blockage ratio, not more than 5% and the space for fixing the required instruments for the wind tunnel analysis [2,3].

II. SPORTS AERODYNAMICS WIND TUNNEL

A wind tunnel is usually used for the research in Aeronautical, Space and Automobile models like airplanes, wings, rockets, missiles, cars, and trucks [2]. In recent developments in wind engineering, building aerodynamics and sports aerodynamics leads a lot of innovation in the development of the wind tunnel facility [2,3].

In sports aerodynamics wind tunnel the great challenge is to be large enough to study athletes, the length must be large to study the flow stream after the ball and to study the wind characteristics and ventilation inside the stadium[2].

The Education wind tunnel facility aim is to give knowledge and academic activities for students. We will facilitate the wind tunnel for studying sports products like different balls, shuttlecocks, frisbee, disc and apparel analysis with a feasible budget.

III. WIND TUNNEL DESIGN AND DEVELOPMENT

All low-speed Subsonic open circuit and suction type wind tunnel consist of the four main parts honeycomb with settling chamber, convergent

January - February 2020
ISSN: 0193-4120 Page No. 3244 - 3247

section, test section, and divergent section. honeycomb with settling chamber will make the flow steady, linear and laminar flow into the wind tunnel[2,3]. The convergent section will reduce in cross-section area when the flow move to the test section will increase the velocity of the flow. The test section will be large enough to fit the model and measuring devices. The test section leads to the divergent section of the reduction of cross-section area with an increase in length to reduce the velocity of the flow, to avoid vibration and stress on the air suction fan blades [3].

Fig. 1. Low-speed Subsonic open circuit and suction type wind tunnel in TNPESU

Fig. 2. Honeycomb and settling chamber

The wind tunnel has a suction type, ten blade fans have coupled with an AC motor (3Ph, 440V, AC supply) with 7.5 Horse Power at maximum 1480 rotation per minute (RPM) will lead maximum flow velocity of 20 m/s in the test section.

Fig. 3. Wind tunnel fan with 10 blades

The wind tunnel different ball models have developed for education and research purpose. Each ball model was facilitated with pressure and force model. The pressure models will have a valve to connect with a multi-bank manometer or the computerized pressure transducer[4]. The force model to be fixed in Strain Gauge Balance for the measurement of the three axial forces and three moments of the model[5].

Fig. 4. Force model on the left and pressure model

IV. Wind Tunnel Measuring Instruments and Devices

To measure the flow characteristic like pressure, flow velocity, force acts on the model and the flow streamline pattern are in need of measuring instruments and devices. The inclined multi-bank manometer filled with alcohol or water with 13 tubes will help to measure the even a small pressure difference at the model. The pitot-static tube with a

TEST Engineering & Management

January - February 2020
ISSN: 0193-4120 Page No. 3244 - 3247

separate manometer will measure the flow velocity in the test section through static and stagnation pressure readings[4,5]. The pitot-Static tube will move vertically up and down to verify the effect of the boundary layer due to the wall of the wind tunnel. The D3D Camera is set to observe and record the flow patterns (smoke flow) and rotation of the ball [6]. The Smoke generator will generate the linear smoke flow to visualize the flow separation, circulation and the path of the flow streamline

Fig. 5. Wind tunnel control panel and Muti-Bank

Fig. 6. D3D Wind Tunnel Camera

Fig. 7. Smoke Generator

V. Computerization of Wind Tunnel Analysis

The latest development in the electronic instrument made the wind tunnel experiments easier, faster and accurate measurement. Pressure transducer and the Strain gauge balance play a huge role in wind tunnel experiments.

The pitot-static and the pressure models connected the pressure transducer which will display the flow velocity and pressure on the display and in the computer, where the inbuilt software will have the algorithm for the calculation

Fig. 8. Pitot-Static tube and Hotwire anemometer

The hot wire anemometer used to measure the flow velocity which works on the temperature difference due to the flow velocity in the test section. Used for the accurate measurement of the flow velocity in the test section[4].

The Strain gauge balance is used to calculate the 3 axial forces and 3 moments act on the body [3]. The Strain gauge balance mounting system not only supports the model but also rotate clockwise and anti-clockwise direction to study the different sports ball rotational effect.

January - February 2020
ISSN: 0193-4120 Page No. 3244 - 3247

Fig. 9. Strain Gauge Balance

The computer had the software with an algorithm to calculate the Pressure distribution, forces acts on the body and the CL & CD measurements and to generate the graphs. All readings can be exported in Excel format[5,6,7].

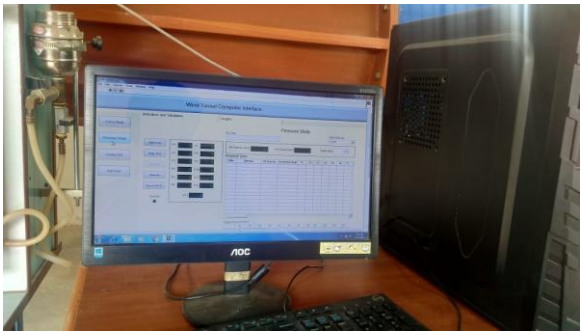

Fig.10. Wind tunnel Computer Software application

VI. CONCLUSION

The wind tunnel is an essential facility for education and research purposes in the Sports Aerodynamics program. The role of the engineer has increased in the development of sports products, infrastructure and athlete performance. Sports technology and aerodynamics skills will lead to a lot of research, career growth and the entrepreneur.

The sports aerodynamics wind tunnel test section is long enough to visualize the flow begin the ball models, the rotating force strain gauge balance is fixed and the multi-bank manometer is customized for the ball pressure models.

VII. REFERENCES

[1]. Mikael Bäckström, Peter Carlsson, Jonas Danvind, Andrey Koptyug, David Sundström, Mats Tinnsten; "A New Wind Tunnel Facility Dedicated to Sports Technology Research and Development" Procedia Engg,, 147 (2016), PP, 62-67.

[2]. Asai, T., Seo, K., Kobayashi, O., & Sakashita, R. (2007). Fundamental aerodynamics of the soccer ball. Sports Engineering, 10(2), 101-109.

[3]. Barelle Caroline; "Sport Aerodynamics: on the Relevance of Aerodynamic Force Modelling versus Wind Tunnel Testing" Wind Tunnels and Experimental Fluid Dynamics Research, 16 (2011), PP, 349-368.

[4]. Stefano Mauro, Rosario Lanzafame, Michele Messina, S. Brusca; "Small-Scale Open-Circuit Wind Tunnel: Design Criteria, Construction and Calibration" International Journal of Applied Engineering Research, volume12, Number 23 (2017) pp. 13649-13662.

[5]. Kevin Owen, Andrew Owen "Measurement and assessment of wind tunnel flow quality" Progress in Aerospace Sciences 44(5) 2008:pp.315-348.

[6]. Karthigeyan S, Jai bhavani K S, Jenifer Z "Wind Tunnel Instrumentation System" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 3, Special Issue 4, May 2014.

[7]. Asai, T., Ito, S., Seo, K., & Hitotsubashi, A. (2010). Fundamental aerodynamics of a new volleyball. Sports Technology, 3(4), 235-239.

[8]. V.L. Kakate, D S Chavan, P.B Karandikar, Niraj Mahulkar "Study of Measurement and Control Aspects of Wind Tunnel" International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering vol. 2, Issue 3, 2014

[9]. A.Nishi, H.Miyagi, K.Higuchi; "A Computer-Controlled Wind Tunnel" 1st International Symposium on Computational Wind Engineering (CWE 92), Tokyo, Japan, August 21–23, 1992, pp.837-846.