JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Systematic Survey of Wind Tunnel Test facility in India

Muthu Venkatesh[1]
Rajarajan G [2] Jyothi NT [3] JV Muruga Lal Jeyan[4]
[1,2,5] Lovely professional University
[2] Researcher European international university Paris
[3] President Lips Research Foundation

ABSTRACT:

This paper has a theoretical survey about wind tunnels and the tests that can be undergone under each wind tunnel around different organisations in India. The applications and special features of each wind tunnel are also noted down in this survey. Many wind tunnels have been established and some of them are not in use right now, due to their lesser capabilities and the invention of new wind tunnels which has more advanced features than the old ones. India is achieving more than great in Aerospace Industry with a good and minimum budget as compared to other countries. India has more wind tunnel testing facilities to get sufficient and important aerodynamic information on a small-scale model of a large-scale aircraft. It is important to run such tests so that the aircraft is aerodynamically efficient, and safer. With the help of wind tunnel testing, engineers can get a clear-cut idea about how to make the aircraft better by taking note of components such as lift, drag, and pressure acting on the small-scale model. Through this paper, you can get systematic and detailed information about wind tunnels and the tests conducted in India.

INTRODUCTION:

A wind tunnel is a device that generates different speeds of airflow through a test segment. Wind tunnels are commonly used in aerodynamic research to study the behavior of flows in channels and across solid surfaces under various conditions. Aerodynamicists can utilize the wind tunnel's controlled environment to measure flow conditions and forces on aircraft models as they are being developed. The air is usually moved through the tube by strong fans. The thing to be tested is securely placed in the tunnel, preventing it from moving. A miniature model of an aircraft could be a single component of a vehicle, It might be a full-scale plane or a spacecraft. It may even be something as simple as a tennis ball. The air moving around the static object represents what would happen if the object were in motion. The movement of air can be examined in a variety of ways. Smoke or dye can be thrown into the air and seen how it is moving about. The force of the air on the object is frequently measured with special devices. Engineers can use diagnostic data from models to adjust designs for better aerodynamic performance without any need to develop a lot of completely functional prototypes. There are several types of wind tunnels (subsonic, transonic, and supersonic wind tunnels), and each type of wind tunnel has its own sub types. Many big organizations in India like DRDO, ISRO, and IITs have state-of-the-art facilities for aerodynamic research, which are helping us reach milestones in the aerospace sector.

SURVEY - 1

Title of the Aerospace Test	**0.3 m Trisonic Wind Tunnel**
Name of the Organisation	CSIR
Name of the Lab	National Aerospace Laboratories - NAL
Place of the Lab	Banglore
Category of Aerospace Test	Wind Tunnel Testing
Sub - Category of Aerospace Test	NA
Year of Establishment	1996
Test Applications	Intake studies-buzz control Shock boundary layer interaction studies PSP Studies Density field studies
Test Special Features	Test section size: O.3x0.3 m Supersonic 0.381x0.3 m-Transonic Mach number range:0.2-4.0. Operation Intermittent blow down type Reynolds number range 8 x 106 to 60 x 106 / meter Model support Sting. Wall-mounted
Other Test Information	Measurement capability: Conventional Digital manometer. 32 port ESP scanner. 35 channel simultaneous unsteady pressure DAQ Flow Visualization: Surface oil flow. Dynamic Schlieren Flow Diagnostic: Pressure Sensitive Paint (PSP). Background Oriented Schlieren (BOS) Experimental Aerodynamics Division - EAD

SURVEY - 2

Title of the Aerospace Test	**0.3 m Hypersonic Shock Tunnel**
Name of the Organisation	ISRO
Name of the Lab	Vikram Sarabhai Space Centre - VSSC
Place of the Lab	Thiruvananthapuram
Category of Aerospace Test	Wind Tunnel Testing
Sub - Category of Aerospace Test	Hypersonic Wind Tunnel

Year of Establishment	1980
Test Applications	Aerospace, R&D Types of test performed: Heat transfer measurements
Test Special Features	Test Section size and shape: 0.3 m diameter - Enclosed jet Speed range/ Mach number range: 6 to 10 Total Enthalpy range: 3 MJ/kg Test Control Parameters: Typical duration: 4 ms Stagnation pressure: 40 bar driver pressure Temperature range: 3000K
Other Test Information	Type of Tunnel: High speed, Intermittent blow down type. and Horizontal Instrumentation: Fast response transducers. Heat flux gauges. Thermocouple 12 channel high-speed DAS

SURVEY-3

Title of the Aerospace Test	**5” x 7” supersonic wind tunnel**
Name of the Organisation	IISc (Indian Institute of Science)
Name of the Lab	Department of Aerospace Engineering
Place of the Lab	Bangalore
Category of Aerospace Test	Wind Tunnel Testing
Sub-Category of Aerospace Test	Supersonic Wind Tunnel
Year of Establishment	1980
Test Applications	Aerospace,
Test Special Features	Test Section size and shape: 5" X 7” Mach number range: 2D convergent-divergent nozzle of M=1.2 to 4 Reynolds number range (per m: 1.3x10 10 Test Control Parameters: Test duration 605 Constant stagnation pressure (ambient) Constant stagnation Temperature (ambient) Vacuum tank volume of 30Om3 at 1 Torr Pressure measurement capabilities with ESP scanner, Kulite, individual chip-based transducer like Honeywell Measurement Computing, etc.

	350mm dia vacuum isolation knife edge gate va
Other Test Information	Type of Tunnel: Intermittentindraft type. Instrumentation: Color Schlierenvideo recording system Data Acquisition System: 1616 FS Measurement computing US8 based data acquisition system Dasylab software for data capture.

SURVEY-4

Title of the Aerospace Test	**Flight Demonstration Wind Tunnel**
Name of the Organisation	ISRO
Name of the Lab	Indian Institute of Space Science and Technology (IISST)
Place of the Lab	Thiruvananthapuram
Category of Aerospace Test	Wind Tunnel Testing
Sub - Category of Aerospace Test	Subsonic Wind Tunnel
Year of Establishment	1968
Test Applications	Primarily for indigenous development testing Testing requirements of R& D organizations and other industries For both aeronautics & non-aeronautical applications Types of tests performed: Steady and Unsteady force & moment measurements Steady and fluctuating pressure measurements Wind Engineering Flow visualization Flow diagnostic tests Special tests: Ground effect measurements Component loads measurements Efflux trails for ship models Stores release (gravity drop)
Test Special Features	Type of Trunnel: Closed Circuit. Closed jet, continuous flow subsonic wind tunnel Test Section size and shape: 2.74 m x 1.83 m, octagonal speed range/ Mach number range: 10 - 55m/s Reynolds number range (per m): 0.63-3.46 million Free stream turbulence level (If low-speed tunnel): 2% Test control Parameters:

	Pitch angle (normal testing): 18 degrees to 42 Yaw angle (normal testing):- 28 degrees to 28 Typical test duration: 15 min High angle of attack testing:- 90 degrees
Other Test Information	Data Acquisition System: Industrial PC based DAS making use of NI simultaneous sampling 16 BIT ADC NI DAQ and Lab View platform for Acquisition In house developed software for acquisition, processing and presentation Special test rigs and test techniques developed: High angles of attack rig Smoke trials at very low speeds Gravity release technique Oil dot technique Ejector developments Milestones achieved: More than 37 projects and 51 models tested since inceptions Completed all the low-speed test requirements for major projects like ALH, IJT. LCH, P-17. P-28, AMCA, HTT-40. FGFA

SURVEY-5

Title of the Aerospace Test	**High-Speed Tunnel**
Name of the Organisation	DRDO
Name of the Lab	Defence Research and Development Laboratory - DRDL
Place of the Lab	Hyderabad
Category of Aerospace Test	Wind Tunnel Testing
Sub-Category of Aerospace Test	Supersonic wind tunnel
Year of Establishment	1980
Test Applications	Aerospace, Research, and Development, and Industrial

Test Special Features	Test Section size and shape: 300mm x 300mm solid wall test section 340mm dai. Enclosed free jet test section Speed range / Mach number range: Mach 1.4 to 4.0 Reynolds number range (per m): 0.3 x 10^8 to 3x 10^8 Side wall-mounted model testing
Other Test Information	Type of tunnel: High speed and Wind Ranges of Pitch, Roll and Yaw: Pitch(-15 degree to 15 degrees) Typical test duration: 100 seconds Stagnation pressure & Temperature range: 20 bar, 300 K

SURVEY-6

Title of the Aerospace Test	**Hydrodynamics Test**
Name of the Organisation	DRDO
Name of the Lab	Naval Science and Technological Laboratory - NSTL
Place of the Lab	Vishakhapatnam
Category of Aerospace Test	Wind Tunnel Testing
Sub-Category of Aerospace Test	NA
Year of Establishment	NA
Test Applications	A wind tunnel to study the aerodynamic characteristics of surface and submerged platforms and underwater weapons with a test section of 1.5 x 1.5 x 4m.This wind tunnel can produce a maximum speed of 60 m/sec with a 125 kW fan. The Wind Tunnel is equipped with projection manometers. differential pressure transducers. velocity measuring probes, vertical catheto-meters, hot film anemometers, 48 port Scanivalve traversing gear, PC BASED DATA ACQUISITION SYSTEM, and analysis software packages.
Test Special Features	Flow visualization and boundary layer studies for underwater vehicles. Wake survey and velocity distribution behind a body for propulsor development. Pressure and velocity distribution over axis-symmetric body. Estimation of forces and moments on control surfaces of a submerged body. etc.
Other Test Information	Test Section Size: 1.5 m x 1.5 m x 4.0 m long

	Plenum Chamber: 4.3 m x 4.3m x 4.0 m long Contraction Nozzle: Varying from 4.3m x 4.3 m square to 1.5m x 1.5 m square; 4.0 m long Diffuser: Varying from 1.5 m x 1.5 m square to 3.5 m dia; 7.8 m long Fan Size: 3.04 m dia made of CFRP Drive Motor: 125 KW dc motor at 750 rpm Maximum Speed at Test Section: 60 m/sec

SURVEY-7

Title of the Aerospace Test	**Low-Speed Wind Tunnel**
Name of the Organisation	Others
Name of the Lab	Jaypee Wind Engineering Application Centre - JWEAC
Place of the Lab	Guna
Category of Aerospace Test	Wind Tunnel Testing
Sub-Category of Aerospace Test	Subsonic wind tunnel
Year of Establishment	2013
Test Applications	Non-Aerospace and primary for Civil Engineering applications, Industrial and Research and Development
Test Special Features	Test Section size and shape: 3.5 m X 3.0 m X 22.0 m - Rectangular Speed range: 0.5 m/s to 40 m/s Reynolds number range (per m): 3.3 x 104 to 2.67 x106 Expected free stream turbulence: Typically around 10% at a height of about 90 cm under simulated open terrain condition. Terrain Simulation: Simulation of atmospheric boundary layer including the profile of mean velocity, turbulence intensity, and spectrum of horizontal wind speed. Special features of the tunnel: Twin-turn table facility
Other Test Information	Type of tunnel: Closed-circuit, low speed, boundary layer wind tunnel instrumentation: Hot-wire anemometry system: (normal and XY - wire probe) Multi-channel high scan dynamic pressure system (512 channels; 2 Initiums; Scanners with DTC) Standard Pitot tub Six-component base balance

	Strain gauges and accelerometers Special arrangements for the control of turn-table position: 3D-traverse system and fan speed. Data acquisition system/software: Labview, Matlab; PSI pressure measurement systems; ln house development GUI software

SURVEY-8

Title of the Aerospace Test	**Low-Speed Wind Tunnel**
Name of the Organisation	IIT
Name of the Lab	Department of Aerospace Engineering - IITM
Place of the Lab	Chennai
Category of Aerospace Test	Wind Tunnel Testing
Sub-Category of Aerospace Test	Subsonic wind tunnel
Year of Establishment	2012
Test Applications	Aerospace/Non- Aerospace Industrial/Fundamental Research Type of tests performed: Unsteady aerodynamics Velocity measurements Flow diagnostic tests
Test Special Features	Test Section size and shape: 750 mm x 750 mm x 2000 mm Parameter Range: Speed: 25 m/s
Other Test Information	Type of tunnel: Continuous suction type Instrumentation: Flow visualization

SURVEY-9

Title of the Aerospace Test	**National Wind Tunnel Facility**
Name of the Organisation	IIT
Name of the Lab	Indian Institute of Technology - IITK
Place of the Lab	Kanpur
Category of Aerospace Test	Wind Tunnel Testing
Sub-Category of Aerospace Test	Subsonic wind tunnel

Year of Establishment	1999
Test Applications	Aerospace & Non-aerospace, Research & Development, and Industrial. Full-model testing with sting support system Half-model testing with external balance Turntables system for aeronautical and non-aeronautical applications Moving belt ground plane for ground effect simulation Gust and crosswind simulation Aero-acoustic testing Laser light sheet generation system for flow visualization 3D Stereoscopic PIV system
Test Special Features	Steady and Unsteady force & moment measurements Steady and Unsteady pressure measurements Aeroelastic tests Ground effect simulation studies Wind effect on structures including interference effect Low Reynolds number airfoils studies Low-speed air-intake studies
Other Test Information	On model pitch, roll and yaw sensors Roll, Pitch and Yaw (O.01 degree) and Y&Z motion (- 0.1mm) Flex-motion eight axis closed-loop control system PSI scanners(11 Nos. 32 port each) 10. 20 and 70-inch WC with 0.05% accuracy DANTAC streamline CTA system for velocity measurements Hot-wire probes and calibrator RTD, SS sensors and thermocouples for temperature B & K microphone sensors and amplifier for noise measurements 3D Stereoscopic PIV system Light-sheet generation using 6W Ar-lon Laser Image monitoring and recording system

SURVEY-10

Title of the Aerospace Test	**Supersonic Wind Tunnel**
Name of the Organisation	BIT
Name of the Lab	Department of Space Engineering and Rocketry - BIT
Place of the Lab	Ranchi

Category of Aerospace Test	Wind Tunnel Testing
Sub-Category of Aerospace Test	Supersonic wind tunnel
Year of Establishment	2013
Test Applications	Aerospace and Non-aerospace R & D Sponsored projects Thesis for ME and Ph.D. Laboratory classes for students
Test Special Features	Test Section size: 100 mm X 150 mm Mach number range: 2- 3.5 Reynolds number range (per m): 2x 10^7- 10^8 Type of tests performed: Calibration in progress Test control parameters: Angle of attack: O-50 Test duration: 20-sec Stagnation pressure & Temperature range: 8 bar, 300 K
Other Test Information	Type of Tunnel: Supersonic Wind Tunnel (4 inch x 6 inch) (Intermittent) Sponsored by AR & DB, Ministry of Defence Instrumentation Multi-tube mercury manometer Pressure Transducers. Electronic pressure scanner Signal conditioners 3 component Strain gage balance Unsteady pressure pickups (Kulite Make) Schlieren system, Digital Camera, NI Cards Data Acquisition Systems used: PC-based low and high-speed NI DAQ & Labview

CONCLUSION:

The systematic survey of 10 wind tunnels across India has been successfully done. It has been found that all types of wind tunnels have a vast number of features. Government organizations have big facilities and Indian Institutes also have a lot of wind tunnels for research purposes such as velocity measurements, diagnostic tests, Aeroelastic tests, Density field studies, wind engineering, flow visualization, etc. Throughout this paper, the type of tunnel, test section size, and shape, instrumentations, scanners, Mach number range, Reynolds number range, duration of the test, pressure, temperature, angle of attack, and force estimations have been surveyed. Each and every tunnel has some special features for some special purpose, for example, the low-speed wind tunnel of JWEAC has a Twin-turn table facility. This survey is very much useful to get information about what facilities are there in some of the wind tunnels across India.

Reference:

1. Aishwarya Dhara and Jeyan Muruga Lal 2021 IOP Conf. Ser.: Earth Environ. Sci. 889 012068
2. 9. R. Balaji and M. L. Jeyan, "Performance analysis on varies bluff bodies at hypersonic speed," 2020 International Conference on Interdisciplinary Cyber Physical Systems (ICPS), 2020, pp. 62-67,
3. 10. A. Rupesh, J. V. Muruga Lal Jeyan, , "Aerodynamic Design and Flow Analysis of Two Taping Spherical Flow Analyser and Mirror Edge Flow Analyser for Subsonic Wind Tunnel Calibration," 2021 International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT),
4. Ashika Parveen, JV Muruga Lal Jeyan, Jyothi NT "INVESTIGATION OF LEAN DEVELOPMENTS AND THE STUDY OF LEAN TECHNIQUES THROUGH EVENT STUDIES" Internation Journal for Science and Advance Research In Technology, 8(4)
5. P Gopala Krishnan, JV Muruga Lal Jeyan, Jyothi NT "NOVEL EVALUATION OF AIRCRAFT DATA STRUCTURE OPTIMIZATION TECHNIQUES AND OPPORTUNITIES" Internation Journal for Science and Advance Research In Technology, 8(4)
6. 34. J V MurugalalJeyan ,Dr. M. Senthil Kumar , "Performance Evaluation for Multi-Hole Probe With the Aid of Artificial Neural Network" International Journal of Theoretical and Applied Information Technology (JTAIT). ISSN 1992-8645Vol No: 65 , Issue 3 , PP: 665 July 31, 2014
7. J V MurugalalJeyan , Dr. M. Senthil Kumar, "Performance Evaluation of Yaw Meter With the Aid of Computational Fluid Dynamic" , International Review of Mechanical Engineering (IREME). ISSN: 1970-8734, Vol No. 8,Issue 02
8. J V MurugalalJeyan,Krishna S nair , Kavya S nair "The Low Speed Aerodynamic Analysis Of Segmental Wing Profile "International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) ISSN (P): 2249–6890; ISSN (E): 2249–8001 Vol. 9, Issue 4, Aug 2019, 1303–1310