INCAS SUBSONIC WIND TUNNEL

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DOI: 10.13111/2066-8201.2009.1.1.3

Abstract

The INCAS Subsonic Wind Tunnel is a closed circuit, continuous, atmospheric pressure facility with a maximum speed of 110 m/s. The test section is octagonal ,of 2.5 m wide, 2.0 m high and 4 m long. The tunnel is powered by a 1200 kW, air cooled variable speed DC motor which drives a 12 blade, 3.5 m diameter fan and is equipped with a six component pyramidal type external mechanical balance with a 700 Kgf maximum lift capacity.
The angle of attack range is between -45º and +45º while the yaw angle range is between -140º and +216º .
The data acquisition system has been modified recently to allow the recording of all test data on a PC - type computer using LABVIEW and a PXI – type chassis containing specialized data acquisition modules.
The tunnel is equipped with a variable frequency electrical supply system for powered models and a 10 bar compressed air supply for pneumatic flow control applications.
In the recent years the subsonic wind tunnel has been intensively used for tests within several European projects (AVERT, CESAR and others).

Introduction

The 2.5 m x 2.0 m Subsonic Wind Tunnel is the first aerodynamic facility at INCAS.

Fig. 1 . Subsonic Wind Tunnel

Its main characteristics are the following:

- Prandtl type, horizontal single return
- Closed test section, atmospheric
- Test section size: 2.5 m wide by 2 m high
- Speed range: from 7 to 110 m/s
- Angle of attack range: -45º to +45º
- Yaw angle range: -140º to +216º
- Reynolds number (for $l = 0.1\sqrt{S}$): $1x10^6$
- Contraction area ratio: k = 10
- Turbulence factor: 1.11

The most usual tests involve forces and moments measurements using the external TEM balance, followed by pressure distributions using the existing classical and electronic scanning devices and flow visualizations using smoke, tufts and oil paints. Laser sheet visualizations have been performed recently with spectacular results.
Apart from the usual measurements of aerodynamic forces, pressure distributions and visualizations on models of aircraft, missiles, cars, buildings, bridges etc., there have been many special test programs like, for instance wind turbines (tested in the large area settling chamber of the tunnel), sky divers, skiers, cyclists, flag masts etc.
The whole experimental activity in the Subsonic Wind Tunnel is carried out according to the existing "Manual for Quality Assurance in the Subsonic Wind Tunnel".

Description of the facility

The tunnel is powered by a 1200 kW, air cooled variable speed (up to 800 rpm) DC motor which drives a 12 blade, 3.5 m diameter fan.
The pressure drop across the fan blades is 210 Kgf/m^2.
The motor air cooling is done by means of a special circuit equipped with a 20 KW fan.
The DC motor is fed by a thyristor controlled rectifier system connected to a 6 KV, 2 MVA transformer.
The tunnel operation, air speed, model positioning and parameter measurements are controlled from an integrated control panel.

Fig. 2 . The control panel

The measured parameters are dynamic pressure, air temperature, model angle of attack and yaw, balance readings, scanivalve position and readings etc.
The tunnel control system includes a sensor for monitoring the DC motor coil temperature, a sensor for monitoring the temperature of the thyristor rectifier, sensors for monitoring the pressure drop across the fan blades, motor RPM indicators and others.
The model is usually installed on the external balance using, if necessary, one or more of the existing 3 faired connecting pods. The model angle of attack is set by moving the downstream pod up or down while the yaw angle is set by rotating the whole balance around its vertical axis.
Model position is measured using precision optoelectronic devices (encoders).

Instrumentation

Force Measurements

Force and moment measurements (up to six components) are made using the external pyramidal type six - component balance built by the British company TEM .
The capacities of the balance are shown below:

- Lift: - 200 Kgf to +700 Kgf
- Drag: - 100 Kgf to +200 Kgf
- Side force: -200 Kgf to +200 Kgf
- Pitching moment: - 110 Kgfm to +110 Kgfm
- Rolling moment: - 110 Kgfm to +110 Kgfm
- Yawing moment: -110 Kgfm to + 110 Kgfm

Fig. 3 .TEM six-component balance

The accuracy of the balance is of 1/25000.
The balance calibration is checked periodically using the existing air bearings and calibrated weights.

Pressure Measurements

The dynamic pressure is measured by means of a precision Q-Beam U - type manometer, maximum range 600 mm of water column, 0.1% accuracy.
Pressure distributions on the tunnel walls and/or the model surface are determined using the existing 48D3 scanivalves equipped with ±1 or ±5 psid transducers and/or electronic scanning devices type DSA-3217 (4 units), having 16 transducers of ±1 psid capacity, from Scanivalve Corporation.
A rake with total pressure probes can be installed vertically downstream of the model.

Visualization Systems

Flow visualizations are regularly performed by one of the following techniques:

- Smoke visualizations using the AEROTECH smoke generator
- Boundary layer visualizations using oil paints
- Visualizations using tufts
- Laser sheet visualizations.

Data acquisition system

The wind tunnel is equipped with a high speed, high accuracy data acquisition system controlled by a PC computer.
The Data Acquisition System is based on a National Instruments 8 slot PXI 1042 chassis which provides the 10 MHz clock for synchronisation of the existing modules:

Fig. 4 . Data acquisition system

- PXI 6025E data acquisition module, 16 channels (SE), 12 bit ADC resolution, 200 KS/s used for the mechanical scanivalves and other analogical output sensors
- PXI 4351 High Resolution Temperature and Voltage Logger, 16 voltage (differential) or 14 thermocouple inputs; up to 60 readings/s, 24-bit ADC resolution (5½ digits), 8 digital TTL
- Two PXI-6508 Digital I/O modules with 96 TTL channels each, used as a digital interface to the existing measuring system for the balance, Q-beam, model position.

The system software consists of on-line programs for Wind Tunnel control and data acquisition and extensive after run data reduction and presentation software.

The Compressed Air Equipment

The tunnel is equipped with an auxiliary Ingersoll-Rand helicoidal compressor type UP5E-22E-10, having a maximum exhaust pressure of 10 barg, maximum mass flow 3.45 mc/min, driven by a 22 kW electrical motor. The air is dried to a dew point of 3ºC by a fully automated Ingersoll Rand dryer type D240IN and fed into a vertical tank of 3 mc capacity. The system is provided with flow meters and regulators adequate for flow control applications.

The electrical supply for powered models

The tunnel is equipped with a special variable frequency AC electrical supply for electrically powered models. This system has been used during certification tests for Aerospatiale with an ATR 42 powered model.

Fig. 5 . The electrically powered ATR model

Hot Wire Thermoanemometry

The laboratory is provided with a DISA hot wire thermoanemometer with two measuring channels, each of them consisting of a 55M01 main unit, a 55M05 type power pack and a 55M11 booster adapter. The system contains also a 55H01 type traversing mechanism controlled by the 52B01 control unit and the 55D90 calibrating equipment consisting of the 55D45 nozzle unit, the 55D44 pressure control unit and the 55D46 pressure converter.

The system is provided with hot wire and hot film probes allowing measurements of mean and fluctuating velocities from a few cm/sec. to 350 m/sec.