Advanced Measurement Techniques at High Reynolds Number Testing in the European Transonic Windtunnel
EUROPEAN TRANSONIC WINDTUNNEL GmbH
Köln-Porz Germany

CRYOGENIC TEMPERATURES
and
MODERATE PRESSURE INCREASE

Flight Reynolds Number Testing Capability
Temperature Range: 310 K > 110 K
Pressure Range: 115 kPa > 450 kPa
Mach Number Range: 0.15 > 1.30
Test Section: 2.4 m x 2.0 m
STANDARD MEASUREMENT TOOLS

Strain Gauge Balances

Incidence Measurement Units

Pressure Scanners

SINCE 10 YEARS IN OPERATION
ADVANCED MEASUREMENT TECHNIQUES

Wing Deformation Measurement

Temperature and Pressure Sensitive Paint

Flow Visualization and Measurement
Independent Variation of Tunnel Parameters

Pseudo Reynolds Number Effects

Ambient Temperature Facilities

Pure Reynolds Number Variation

Aeroelastic Effect at const Re
Wing Deformation Measurement

M  ReC  Pt  Tt  Q  Alpha
(Mio)  (kPa)  (K)  (kPa)  [°]
0.85  20   164  115  52  1.98
0.85  20   215  140  68  1.94
0.85  20   321  184 101 1.93

Twist and Bending
Stereo Pattern Tracking System
Half Models

upstream

downstream
Application of Markers at Half Span Model

LETRASET Markers:

- Circular dots, approx. 15 pixels in diameter

- More markers near wing tip to compensate for chord length

- Good contrast to background
Wing Twist and Bending Measurements

Twist 1.2 deg

Bend 42 mm

Lift
Calibration Frame for Full Span Models
Temperature and Pressure Sensitive Paint

TSP

PSP
Transition Detection by Temperature Sensitive Paint
Transition Detection by Temperature Sensitive Paint

First step for future PSP
Verify Required Equipment
Investigate Handling and Tools
Development of Transition with Reynolds Number

Ma = 0.785
CL = 0.5

Re = 6 Mio
10 Mio
12 Mio
17 Mio
European Transonic Windtunnel

Pressure Sensitive Paint
First Check-Out in Pilot Facility PETW

2d Profile

PSP Camera and Flash Light
PSP - PETW Check-Out

Oxygen Injection Capabilities

Control Stability of different Oxygen Concentration

Acquisition of Images at different Test Conditions

Check-out of TSP Equipment

Test Preparation and Handling

\[ T_{\text{tot}} = 230 \text{K}, \quad P_{\text{tot}} = 120 \text{ kPa}, \quad \text{Ma}=0.79 \]
Pressure Sensitive Paint
First Test in ETW
PSP - First Test in ETW in October 2004

Oxygen Vapourizer during Operation
0.5 Nm³/sec

Oxygen Pipeline in Tunnel Building
PSP - First Test in ETW in October 2004

First successful test in ETW

300 K – 160 K up to 340 kPa

Oxygen Injection with manual control

Stabilisation of Oxygen Level at requested amounts of 700, 1000 and 1500 ppm

Images successfully acquired

Surface roughness of paint 0.3μm
Flow Visualisation and Measurement

Doppler Global Velocimetry

Laser Light Sheet

Background Oriented Schlieren
LASER Systems require Seeding

**ETW** - wind tunnel without particles

Seeding with ice particle below 240 K

April 2005  Aerospace Testing Expo
Wake Measurement - DGV System

MDAW Project

April 2005
Aerospace Testing Expo
Laser Light Sheet Background Oriented Schlieren

Reynolds Number Influence on Wake Vortex Position

LUFO - AIRWI DLR
Laser Light Sheet (LLS)

1 Light Sheet – 2 Observation cameras

flow

LS

Region of Interest

o1

o2

April 2005

Aerospace Testing Expo
Background Oriented Schlieren (BOS)
Further Development

- **Pressure Sensitive Paint** for cryogenic conditions
- Standard operation of optical systems for
  - Model Deformation Measurement
  - Flow Visualization
- Testing tools for **Aeroelastic Investigations**
Importance of
FLIGHT REYNOLDS NUMBER TESTING

demonstrated

High Standard on
TESTING TECHNIQUES

achieved

Further Improvement on
PRODUCTIVITY and COST EFFICIENCY