ETW NEWS

EUROPEAN TRANSONIC WINDTUNNEL

Issue No. 14 | December 2006

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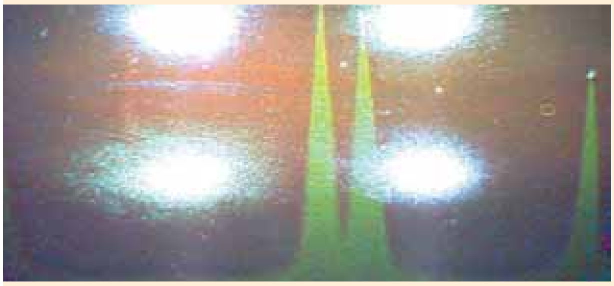

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ADVANCED DOWNWARD POINTING WING TIP DEVELOPED

In the framework of the European Aeronautics Vision 2020, the project M-DAW (Modelling and Design of Advanced Wing Tip Devices) has been worked on by a group of European industry and research organizations. Theoretical work included the study of flow physics, application of CFD, novel Wing Tip Design and was accompanied by tests at high Reynolds numbers in the ETW.

The aerodynamic advantages of specially formed devices at the wing tips are only useful if the penalty by their weight and the structural consequences of the increased wing root bending moment are sufficiently small.

An advanced Downward Wing Tip design has been developed, evaluated and compared to conventional devices such as large dihedral winglets and (triangular) fences at the wing tip. This novel downward wing tip design was extensively tested at high and low speed in the ETW including wing deformation measurements and its favourable overall performance has been broadly confirmed.

The M-DAW conclusions, considering the test results in the ETW, are:

- A novel downward pointing winglet has been developed that achieves a similarly low drag and bending moment as a wing tip fence due to the changed lift vector, whilst also offering an attractive low speed benefit.

- Final M-DAW devices, whilst not exploiting revolutionary flow physics, do demonstrate a useful expansion of design space.

- Downward pointing winglets can be added to the catalogue of useful wing tip devices.

FLOW VISUALISATION
by means of Liquid Crystals

Several flow visualisation techniques are available at ETW. Minituft flow visualisation, Temperature Sensitive Paint (TSP) and the Acenaphthene sublimation technique are considered to be mature test techniques available for use over extensive ranges of test conditions. ETW undertook further investigations to provide clients with an additional tool for transition and separation detection: Liquid Crystals.

The development of tools providing detailed information on flow behaviour is important to complement CFD giving more accurate results on flow characteristics like transition and separation. ETW undertook several trials with different types of Liquid Crystals in the pilot facility (PETW) and found at least one being appropriate for testing in a client test campaign in ETW.

The Liquid Crystals used were thermochromic cholesteric crystals, which can be divided into two major classes; firstly temperature sensitive crystals and secondly shear sensitive (temperature insensitive) crystals. Both types were applied to a 2D profile and tested in PETW. The most promising results were achieved with the shear sensitive crystals which were subsequently tested in ETW.

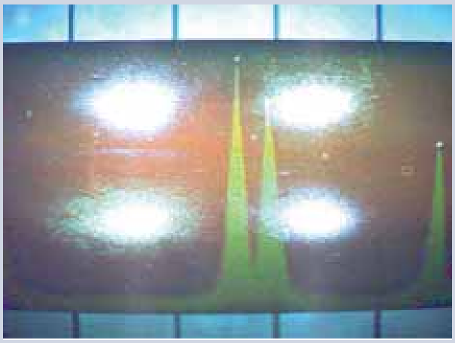


Figure 1

Shear Sensitive Liquid Crystals

Different mixtures of shear sensitive Liquid Crystals were tested in PETW at ambient conditions. As can be seen from Figure 1, the colour response of shear sensitive crystals is achieved directly when starting the tunnel, where wedges of turbulent boundary layer flow (created by dust particles on the surface) can be seen clearly. Figure 2 shows the capabilities of Liquid Crystals in transition detection at tunnel conditions Mach 0.3, Alpha= 5deg at Ttot= 290K.

Figure 2

With the objective to determine flow separation, additional tests were performed with minitufts applied and transition fixation on one half of the profile. Flow characteristics such as shock position (left profile half) and separation at the trailing edge region (indicated by minitufts on the right half) are indicated very well by the crystals for the Mach 0.74 conditions, shown in Figure 3.

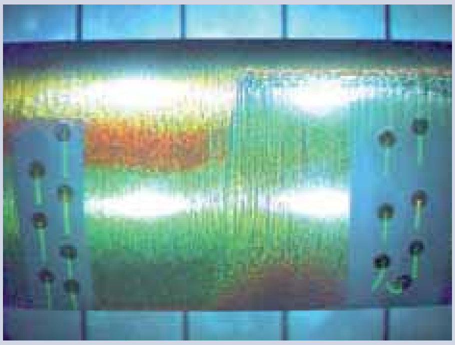


Figure 3

Application of Liquid Crystals in ETW

By the end of 2005 Liquid Crystals were used as a flow separation detection tool on a full model in a client test campaign. Results were very encouraging and further investigations are ongoing, including fundamental research activities on the development of cryogenic Liquid Crystals for high Reynolds number testing.

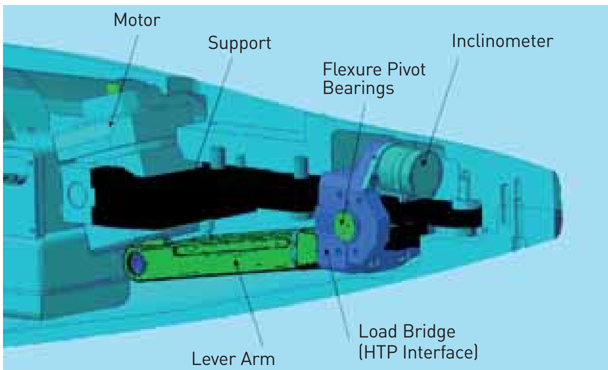
THE NEW HTP REMOTE CONTROL SYSTEM

HTP setting changes at cryogenic temperatures

Providing a significant increase in productivity and efficiency at ETW, the new Horizontal Tail Plane (HTP) Remote Control System was successfully tested on a full model mounted on ETW's Twin Sting Rig. Within the REMFI test campaign tests were performed over the complete temperature envelope including extensive testing at cryogenic conditions at 115K. HTP setting variations were performed in the range -2 to +2deg in the ETW test section.

Within the REMFI project, an EU funded multinational project with the main objective on rear fuselage flow investigations, a great variety of different rear end configurations were tested. Configurations included investigations on the HTP efficiency, VTP rudder and HTP elevator settings. As a fundamental prerequisite the test programme incorporated HTP setting changes with the Remote Control (RC) System in the ETW test section resulting in higher productivity and efficiency, and therefore reducing test costs tremendously.

ETW was responsible for the development of the Remote Control system in cooperation with the REMFI partners Airbus Spain and Airbus Germany in order to define interfaces and match the needs and requirements of each partner. Airbus Germany undertook the re-design of the rear fuselage, and Airbus Spain modified the existing HTP design resulting in a completely new approach to HTP fixation and pressure routing.



The design was quite challenging due to the high standard of accuracy required, the very high loads to be coped with and the very limited space available. On top of that the system had to provide the possibility to route HTP pressures into the inner rear fuselage, resulting in an innovative and unique design of the HTP/ Load Bridge interface.

The RC HTP system basically consists of following components: The support beam for the attachment of the system in the rear fuselage, the motor for the actual movements, and the Load Bridge, the interface part to which the HTP is mounted to. Being connected via a lever arm, the Load Bridge translates the spindle movements of the motor into angular rotations of the HTP, see Figure 1. The HTP setting angle was controlled throughout all conditions with a dedicated inclinometer attached to the Load Bridge. Innovative flexure bearings made from Inconel were used, since these parts granted operability at cryogenic temperatures.

Since the new approach of the HTP being mounted to a moveable system entailed a reduced stiffness compared to common HTP fixations using inserts, the measurement of the actual HTP setting angle was mandatory for all test conditions. The maximum deviation measured during a polar with high loads was in the order of 0.15 deg, which was fully acceptable for the customers.

The Remote Control System showed excellent performance during the entire test campaign. All HTP setting changes were performed successfully at both ambient and cryogenic temperatures resulting in a significant reduction of test duration and cost.

MODEL DEFORMATION MEASUREMENT

SPT measurements on a Twin Sting Rig mounted Model

Full model rear end investigations are usually performed with the Twin Sting Rig model support in order to minimize support interference effects. Since the support booms are attached to the wings, the bending and twist characteristics of the model are changed completely compared to common single sting supported models. Within the Rear Empenage and Fuselage Investigations (REMFI) project the wing and HTP deformation of a full model mounted to ETW's Twin Sting Rig were assessed with the Stereo Pattern Tracking (SPT) systems.

Originally, the ETW SPT system was developed for half model wing deformation measurements. The application for full models with cameras being installed in the test section top wall was already proven to give excellent results (see ETW News No. 12 and 13). Now, the measurement of wing and HTP deformation on a TSR mounted model using the upper model surfaces was the next step forward.

The basic principle of the SPT system is that two cameras look at a wing/ HTP surface with two different viewing angles. The system monitors the position of each individual marker applied along the leading and trailing edge within a previously calibrated volume and computes the 3D coordinates. By recording reference images wind-off, the coordinates can be transferred into bending and twist, typically for the semi-chord line.


Figure 1

Within the REMFI test campaign two independent systems were used to measure the starboard wing and the starboard HTP deformation. Tests were performed for three different HTP settings at two levels of dynamic pressure and ambient temperature.

The standard SPT system was used for the wing, while the HTP deformation measurement required the Enhanced SPT system. The Enhanced system (ESPT) was developed for focussing on smaller objects like flaps, winglets and also HTPs. Since the field of view of the lower model surfaces was very limited by the support booms, the deformation was measured by monitoring markers applied to the upper surfaces, shown in Figure 1.

In order to achieve a high accuracy of the results the density of the applied markers increased towards the tip region. Additionally, a smaller marker size was chosen for the HTP to allow the application of a maximum of 40 markers to be monitored.

All SPT measurements were performed successfully and the wing and HTP deformations were assessed with a high level of accuracy.

Figure 2 and 3 show typical results for the wing and HTP twist measured with the ETW SPT systems.

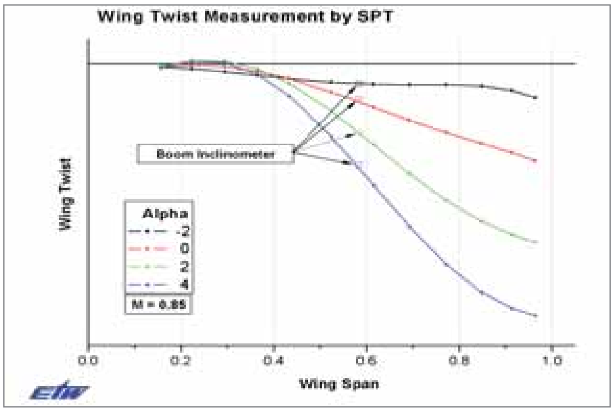


Figure 2

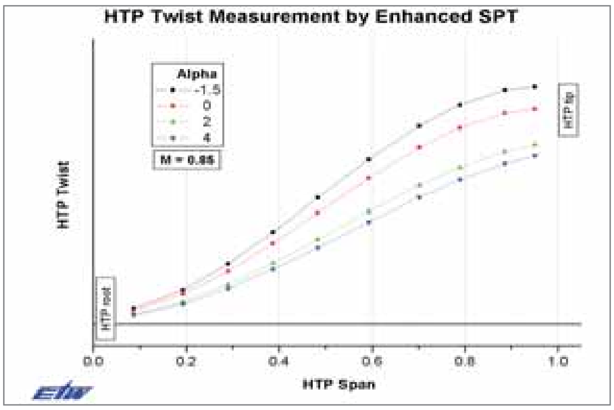


Figure 3

AERONAUTICS DAYS 2006

ETW present as Partner within three EU Projects

The fifth European Community Aeronautics Days, a key event for European research and technology in aeronautics and transport, were held 19 -21 June 2006 in Vienna, Austria.

Next to a conference for exchange of results and information on finished and ongoing projects of the European Research Framework Programmes and of national and international research, an exhibition was organized to present additional information on major topics.

In this exhibition, ETW was represented within the projects REMFI (Rear Empenage and Fuselage Investigations), EWA (European Wind Tunnel Association) and Fliret (Flight Reynolds Number Testing) as a partner of the respective international European research groups.

A number of presentations in the conference referred to and described the various setups and the results of the respective wind tunnel tests in ETW.

A major focus of interest for the attending experts, including Janez Potocnik, European Commissioner for Science and Research, was the model of an advanced Airbus transport aircraft configuration with remotely controlled horizontal tail plane which had been extensively tested in ETW at ambient and cryogenic flow conditions.

European Transonic Windtunnel

ETW GmbH · Ernst-Mach-Strasse · 51147 Cologne · Germany · info@etw.de · www.etw.de

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Conferences/Expositions

Aerospace Testing Expo Europe (ETW was represented with a stand in the Exposition) April 2006, **Hamburg, Germany**, Technology Forum

- Deformation Measurement at High Reynolds Number in the European Transonic Windtunnel (ETW)
  D. Schimanski (ETW)

5th European Community Aeronautics Days 2006, Conference and Exhibition June 2006, **Vienna, Austria**

- Horizontal Tail Plane & HTP Remote Control System with Elevator – Rear Fuselage Gap Sealing System Designs
  J. de Pablo Pérez (Airbus ES), M. Schultz (ETW), B. Hildebrand (ETW)

25th International Congress of the Aeronautical Sciences (ICAS) September 2006, **Hamburg, Germany**

- Performance Testing with High Productivity in a Low Speed Flight Reynolds Number Test Campaign
  R.C. Griffiths (Boeing), M.C.N Wright (ETW)

Aerospace Testing Expo North America (ETW was represented with a stand) November 2006, **Anaheim, Cal. USA**

- Capabilities of Measurement Techniques for Establishing High Quality Aerodynamic Data in Flight Reynolds Number Testing Conditions at ETW
  D.M. Ansell (ETW)