8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

ETW – Industrial Testing at High Reynolds Numbers

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KEY WORDS: Windtunnel testing, aerodynamics, aerolelastic, high Reynolds number, model support, measurement technique

ABSTRACT

The European Transonic Windtunnel ETW is a pressurised cryogenic facility with slotted walls using nitrogen as test gas. Its capability to lower the gas temperature down to 110K by simultaneously increasing the tunnel pressure up to 450 kPa allows e.g. for Mach numbers of 0.85 achieving Reynolds numbers up to 55 million for full models as well as up to 80 million for half models based on the aerodynamic mean chord. The tunnel can be operated from a Mach number of 0.15 up to a slight supersonic one of 1.35, hence, offering also test capabilities for landing and take-off configuration up to real flight Reynolds numbers of around 25 million. Further on, the individual control of pressure and temperature generates a unique capacity for an individual investigation of pure aeroelastic and pure Reynolds number effects compared to classical facilities as shown in Figure 1.

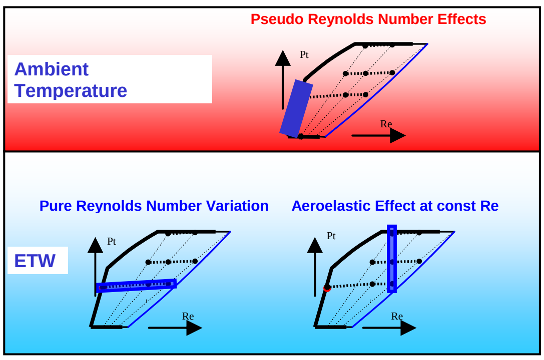

Figure 1: The test capability of ETW (blue) in comparison to a classical "ambient tunnel"

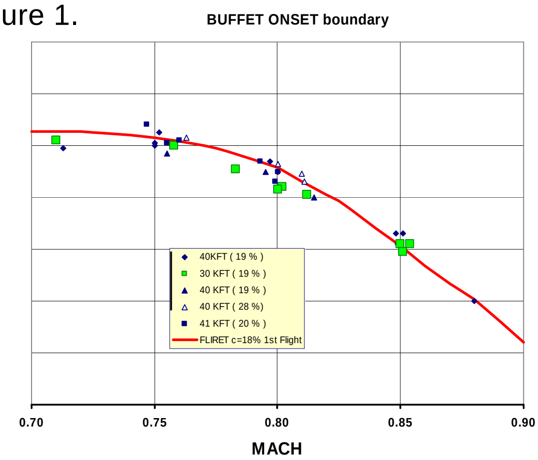

Figure 2: The buffet onset boundary assessed in ETW vs flight results [1]

Since the year 2000 ETW has been engaged in numerous European projects like HiRETT, EUROLIFT, REMFI, M-DAW for high Reynolds number research or to generate a high quality database for CFD validation and code development.

After a period of gathering experience in high Reynolds number testing in ETW the major aircraft manufacturer around the world underline the benefits of such type of test for the design process of new aircrafts. Driven by a high data quality standard, performance measurements on full models have successfully demonstrated the excellent flight prediction capability provided by the facility also, e.g., regarding the buffet boundary as given in Figure 2.

Investigations on high-lift configurations, typically assessed using half models, revealed formerly unpredictable Reynolds number effects as results of high-lift component design and settings.

The tunnel capacity to perform pure aeroelastic effects by a variation of the dynamic pressure only allowed unique aerostructural investigations at Reynolds numbers above 70 million when a half model was artificially exited at different bending and torsion modes.

Testing in pressurised cryogenic environment also demands the availability of suitable measurement techniques for an assessment of model deformation, boundary layer transition detection and flow separation as well as tools for flow analysis preferably optical non intrusive systems.

Relevant develop and adaptation work is going to be performed in a scaled down version (1 : 8.8) of ETW named PETW offering the same operating envelope as the large facility regarding speed, pressure and temperature range.

Within the European STREP project FLIRET (Flight Reynolds number testing) launched in the 3rd call of the 6th framework several aspects related to high Reynolds numbers have been addressed covering on one hand the test environment (model vibration) and model issues (surface roughness, mounting effects on half models). Here, the maximum lift behaviour affected by the Reynolds number and the peniche height could be demonstrated on a half model at low speed. A large part of the project was devoted to the design, manufacturing and experimental validation of supports for full models targeting for a reduction of support interference. One configuration, the front blade sting, revealed an unexpected improvement regarding model stability during test. During all relevant testing the model deformation was carefully monitored using the existing stereo pattern tracking system.

In the framework of other presently running European projects the tunnel is used to simulate the laminar flow development at typical flight Reynolds numbers.

REFERENCES

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