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

Application of Advanced CFD tools for Cryogenic Testing

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KEY WORDS: Numerical wind tunnel, numerical wind tunnel correction, half model mounting effects, high Reynolds number testing, numerical sting design, CFD validation, DLR Tau code.

ABSTRACT

Objectives:

The main objectives of the activities presented in this paper are

- to determine the CFD limits in complex junction flows
- to assess half model test techniques for high lift applications at flight Reynolds numbers by CFD
- to aid in the design of new/improved full model support systems by simulating existing and proposed configurations and by means of shape optimization, using CFD methods

Applications:

The objectives of the present investigation have been achieved using the so called “numerical wind tunnel” with “numerical wind tunnel corrections” developed in an internal DLR project. This technique can be used to identify differences between wind tunnel and free flight conditions in order to improve existing wind tunnel testing techniques (e.g. half model mounting technique) as well as to generate reliable validation data for further CFD-code developments.

For the full model support systems, computations were carried out both with and without model in order to determine support interference and means to reduce it. Main target for was the ETW Twin Sting Rig. In the process, the simulation environment was refined and improved to a state where it is possible to analyse the flow around a model in a slotted wall test section quite precisely using a comparably simple setup.

Results:

Within the EU project FLIRET measurements of the DLR F11 half model as high lift configuration (landing case, Figure 1 & 2) have been carried out in the cryogenic wind tunnel ETW. The measurements were conducted with three different peniche heights to determine the influence of the so called half model mounting effects on the aerodynamic characteristics of model flow.

In comparison to the measurements numerical simulations of this configuration including the complete wind tunnel flow have been carried out with structured and unstructured CFD codes i.e. DLR FLOWer & DLR TAU code). In Figure 3 a first comparison with measurements is shown. Based on these results currently improved numerical simulations are ongoing in order to improve the capability of the used CFD codes to predict the wind tunnel measurement. Details will be shown in the final paper.

Simulations of existing full model support were conducted in order to highlight potential improvements, shape optimisation was performed and new designs were assessed by means of CFD. Most of this work focused around the Twin Sting Rig which was replaced by a new and improved system as part of FLIRET. Figure 4 shows the Mach number distribution around the datum setup.

Future:

The application of advanced CFD tools for cryogenic testing will significantly impact the high Reynolds number wind tunnel techniques with regards to accuracy and reliability of free flight prediction. This will be achieved by aiding in test design, test setup selection and wind tunnel corrections as well as by enabling better understanding of test results.

Figures:

Figure 1: F11 landing configuration in cryogenic tunnel ETW.

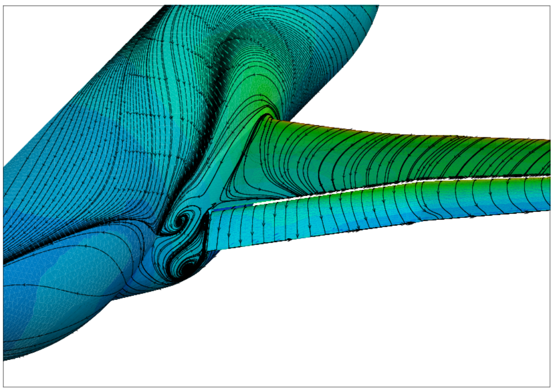

Figure 2: F11 high lift configuration (landing case); surface streamlines and pressure distribution, angle of attack 14 degrees.

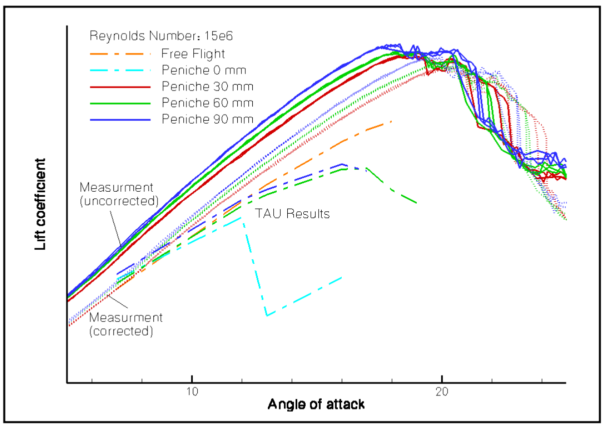

Figure 3: Comparison of measurements (ETW) and numerical simulations with different peniche heights.

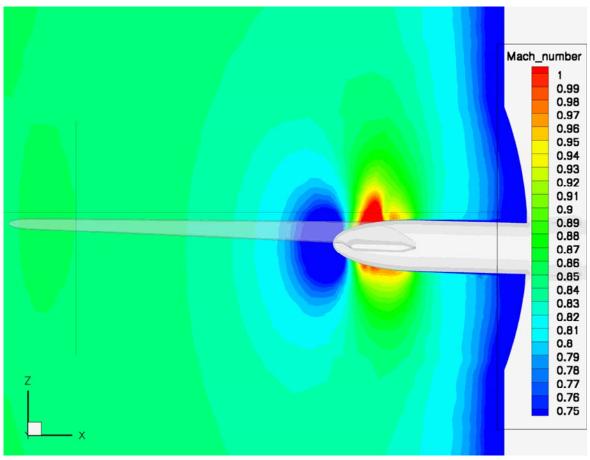

Figure 4: Mach number distribution around the datum Twin Sting support at a reference Mach number of 0.85 and α=1.5°.