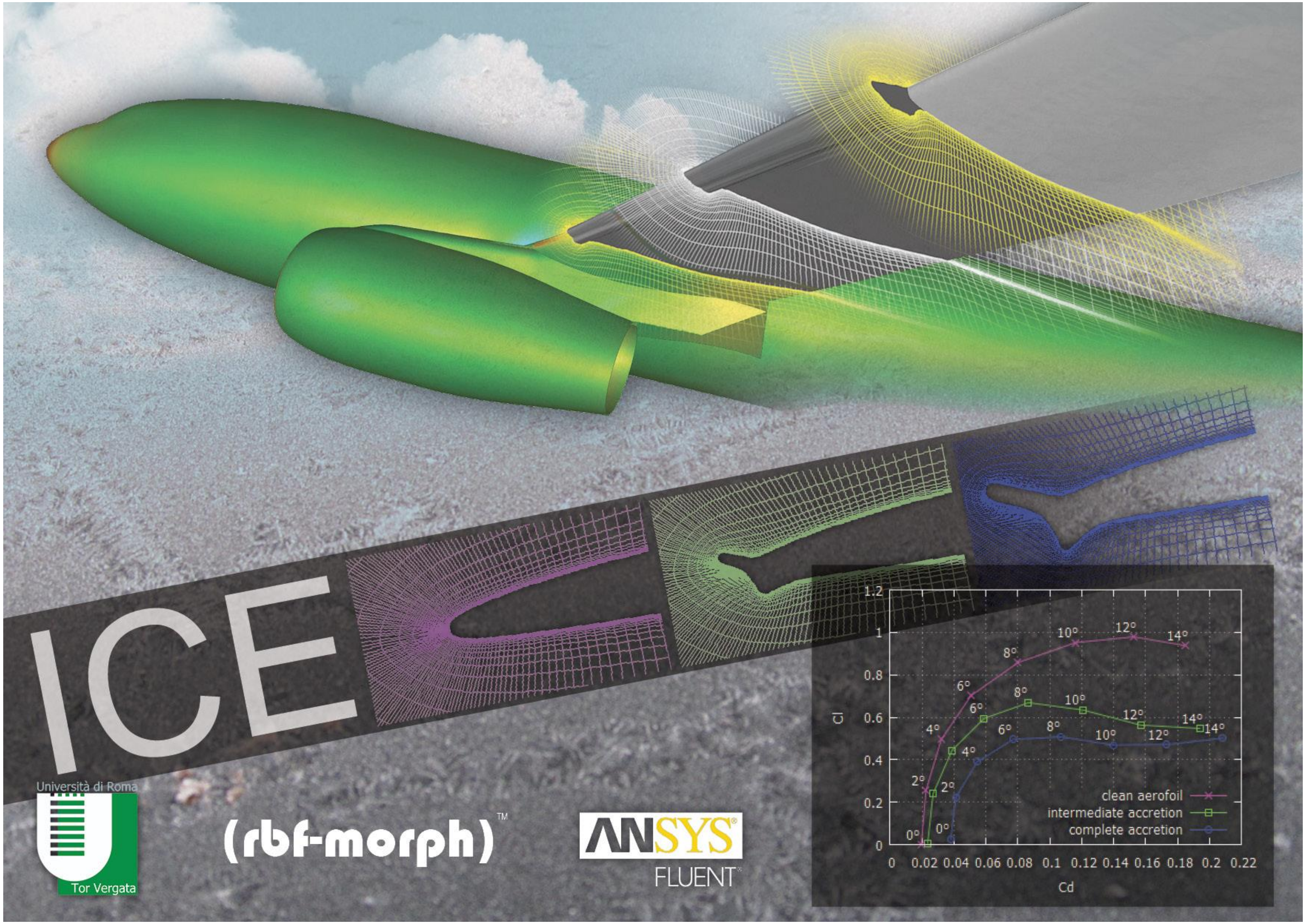
ICE
Università di Roma
Tor Vergata
(rbf-morph)™
ANSYS
FLUENT
Cl
Cd
clean aerofoil
intermediate accretion
complete accretion
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22
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0° 2° 4° 6° 8° 10° 12° 14°

Use of RBF Morph mesh morphing for the estimation of airfoil performances in presence of ice profiles

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CHALLENGE

Flying in icing atmospheric conditions can be a serious safety problem. Ice build-up generally occurs when supercooled droplets impinge on aircraft surfaces, most commonly the engine and the windward face of the wings, causing a variation in the overall vehicle fluid dynamics. Ice accretions can increase the drag force and decrease the lifting characteristics of the aerofoil, so more power and a greater angle of attack is required to maintain flight conditions. Wing Icing causes not only stall to occur at lower attack angles, but an uneven ice distribution that can diminish dangerously the vehicle manoeuvrability.

Wind tunnels can recreate exact ice shapes, but the control over the dimensionless parameters can be very hard. Computational fluid dynamics is widely used because it's a low cost alternative than can simulate relatively good the whole icing process. Although historically NASA and DERA were the main contributors to the numerical models development, nowadays there are several different accretion models from all the major international agencies, such as Lewice (NASA), Trajice2 (DERA), Capta (ONERA), Multi-ice (CIRA) and fensap-ice (NTI). A typical icing accretion model consists of two main modules that work seamlessly together. The first one deals with the droplets trajectory, and determines the collection efficiency distribution over the whole body. The second one computes a thermodynamic analysis to establish, given the collection efficiency, the ice thickness in any given point. Results from the accretion model can be then used to model a new shape in the analysis environment used for the fluid dynamic simulation.

There has therefore to be a direct connection between the ice accretion model and the CFD solver, that can be used cyclically to compute back the flow field for the collection efficiency determination of the new configuration. Being able to generate a high quality grid in the shortest time possible is a major challenge as it is a possible bottleneck of the whole ice accretion analysis in terms of both time and quality.

SOLUTION

This study shows how mesh morphing can be effectively used as a tool for updating CFD models of wings into iced configurations, i.e. accounting for the presence of complex shapes originated during ice accretion. Although several approach are well established for the prediction of ice build up, a robust method capable to continuously update the original geometry into the iced one is a paramount for automate calculation workflows suitable for ice accretion prediction and wing performances degeneration. Thanks to the use of the mesh morphing software RBF Morph and the CFD solver ANSYS Fluent a method for automatic update of the mesh has been implemented. Presented results are based on Lewice 2.0 validation manual. Six benchmark shapes have been selected and the proposed workflow is capable to update the mesh from original to iced configuration (in this case final shapes are known in advance). At each intermediate step the quality of the morphed mesh is monitored. Wing performance is then examined considering both global forces (polar plots) and local Cp profiles. Additional benchmarks were finally carried out to demonstrate the workflow in a tridimensional environment.

http://www.rbf-morph.com/images/download/ugm_2013_cfd_biancolini_rbf_morph_airfoil_performances_ice_profile.pdf

PROMISE

Mesh morphing has proven to be an effective solution for several industrial challenges. RBF Morph is integrated with Fluent and Workbench and allows to implement complex shape optimization workflow in an effective and reliable way. As highlighted by the 50:50:50 project by ANSYS (automotive application demonstrating how 50 shape variations of the Volvo XC60 body can be accurately computed using a 50 million cells CFD model in 50 hours) thanks to mesh morphing the user can go for optimization without sacrificing nor completeness, accuracy or time. This successful approach born in motorsport (Formula 1) is now penetrating the CFD market in several fields, including aeronautical, naval, nautical, medical, civil. Thanks to the fast learning curve of the morpher users can quickly benefit of calculation time compression offered by this technology.

The high accuracy of RBF algorithms used to control the shapes allows to extend the method to the most challenging multi-physic problems. Including fluid-structure interaction, where FEM solutions are used to update the shape of the CFD mesh, and ice/snow accretion where accretion model data are used to locally update the shape of components. Presented benchmark has been conducted in strict cooperation with ANSYS India (Hemant Punekar); the workflow has been successfully implemented in an industrial application (snow accretion on trains).

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http://www.ansys.com/Hall+of+Fame