Thermography in the "Valentino Losito" Air Force Academy Wind Tunnel

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Summary

The main aim is the characterization of the "*Valentino Losito*" Wind Tunnel (VLWT) regarding the implementation of thermographic techniques. It represents the first application of advanced visualization techniques at the VLWT. In fact, thermography allows a modern and complete knowledge of certain boundary layer phenomena: in this work it is focused the attention on transition and separation.

Until now, flow visualizations in the VTWT have been rough because they were carried out with qualitative tools, enabling a limited knowledge on the phenomena above mentioned. This new study has grown the acquisition of more powers and experience of the flow development within the wind tunnel.

Reference has been made to a similar investigation realized in the University of Pisa's wind tunnel, characterized by a smaller test section, exploiting, at the moment, the presence of a wind tunnel of the same type in Campania, that allows to express a greater potential.

The present work consists of three parts, concerning:

I. Boundary layer fundamentals, i.e. transition, separation and heat transfer mechanisms;
II. Design and realization of the model support;
III. Experimental results and comparisons with theoretical and experimental data.

The test article is a low aspect ratio rectangular wing, which leeside surface is coated with a stainless steel foil, glued to the surface by means of epoxy resin. To reduce the effect of reflection from neighboring surfaces, the coating foil is blackened by means of a very thin film of black paint. During the applications, the coating foil is heated by a direct current power supply.

An infraredcamera is employed to characterize the boundary layer development, by measuring the temperature distribution over the heated surface. The Reynolds analogy is used to relate heat transfer to skin friction. The camera is linked to a computer that constitutes the control unit.

The model's support has been built in the Gasdynamic's Laboratory of the University of Naples, and the model, the infraredcamera, the computer and the power supply were made available by the same Laboratory.

The Reynolds number range has been selected in order to have control over the model power. The highest test Reynolds number corresponds to half of the maximum Reynolds number achievable in the test section. Tests have been carried in the range of the operational angles of attack.

For each test, the acquisition of a cold and a hot image of the model is required, where the hot image is realized by powering the model. The optimum acquisition conditions are those in which the model temperature remains as uniform as possible. In the cases of higher velocities, to achieve a temperature steady-state a very long time has needed.

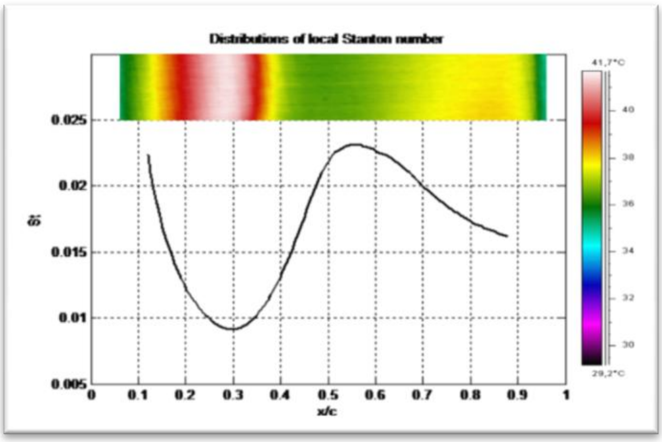
Basic features of the airfoil boundary layer have been captured by exhaustive analysis of thermographic images. It has been observed that transition moves towards by increasing the angle of attack. At highest angles of attack the three-dimensional nature of the flow and stalling characteristics of the wing have been captured. Some tests have been carried out by placing a transition trip on the leeside surface of the wing, to observe the effects of an induced transition compared with the corresponding natural transition. All the thermograms have been post-processed to give a more precise indication on transition, separation and possible separation with turbulent reattachment, by varying the angle of attack and the Reynolds number.

Accurate investigations were made to quantify the entity of radiative losses, which seem to be a small percentage.

Experimental results were also compared to numerical predictions (XFOIL), producing a first estimate of the amplification n-factor about equal to *7* to have a correspondence between both results.

An interesting coming development could be an investigation about the laminar bubbles dynamics on the same wing model.

Some pictures are proposed as examples.



The model wing and the chordwise distributions of local Stanton number over the leeside for $\boldsymbol{\alpha = 12°}$ ($\mathbf{Re_c = 1.11 \times 10^5}$)