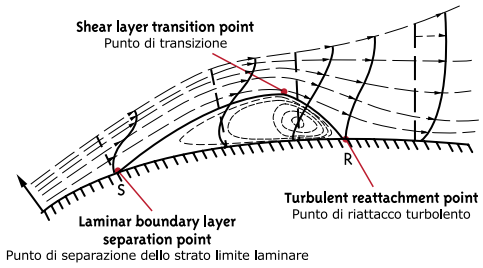
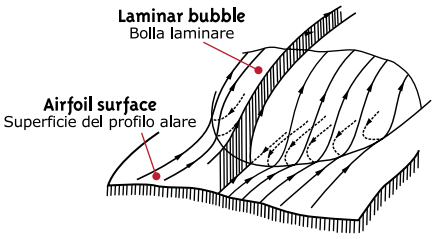
FLIR SYSTEMS

The wind tunnel with the ThermaCAM SC 3000





Schematical overview of the principle of the laminar separation bubble

Università di Ancona-Università di Pescara uses FLIR Systems ThermaCAM™ SC 3000 for thermo-dynamic research.

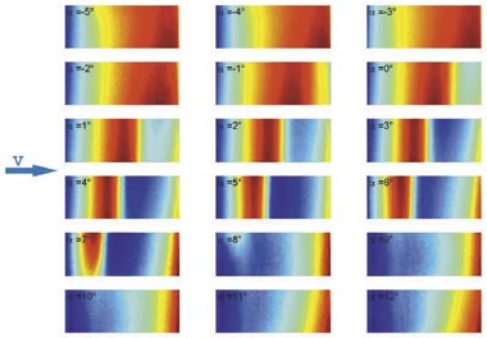
Infrared thermography is being used for numerous applications in Research and Development. The automobile industry, printed circuit board manufacturers and numerous other industries have discovered the advantages of visualizing thermal phenomena in their R&D work.

Also universities are using infrared thermography to do both fundamental and applied research. A perfect example is the research that professor Ricci and Prof. Cesini are conducting at the university of Ancona in Italy.

Laminar separation bubble (LSB) visualisation by infrared thermography

Professor Ricci and his team are using a FLIR Systems ThermaCAM SC 3000 to visualize boundary layer separation phenomena on aerodynamic bodies such as airplane wings, at low Reynolds and Mach numbers, by thermographic investigations. The laminar separation bubble presence is mainly investigated.

A separation bubble is a region of locally separated flow on a body. The extent of this region depends on the



Infrared images of the upper surface of the airfoil for many angles of attack

operational parameters (Reynolds number, angle of attack, free stream turbulence), and airfoil geometry (thickness, camber, surface quality). Depending on a complicated combination among the above quantities the bubble can be short or long, it can contract or extend with the increasing angle of attack.

A long separation bubble usually starts far behind the leading edge and modifies the pressure distribution on the upper side of the airfoil. This type of bubble is associated with a pressure drag increase and a loss in lift. A short bubble is just behind the leading edge, does not alter macroscopically the surface pressure distribution, and changes only slightly the lift coefficient but at high angle of attack an abrupt stall occurs because of the bubble burst. In this case the lift decreases immediately and a very high pressure drag is observed.

The LSB phenomenon occurs when a laminar boundary layer separates in presence of an adverse pressure gradient. If a transition occurs in the separated shear layer a turbulent reattachment could be reached, the separated region is named 'bubble'. This phenomenon may induce a body drag coefficient increase. It occurs, for instance, in sailplanes wing tips and wind turbine blades when these operate at low Reynolds number.

The Experiment

Two small rectangular wings were used in wind tunnel measurements; the first was equipped with pressure taps to carry out standard aerodynamical measurements, and the other has been coated by a thin metal sheet to be used in thermographic investigations with the ThermaCAM SC 3000, through an infrared window placed on the wind tunnel section. An electric supply has been provided at the metal coating to achieve a uniform heat flux boundary condition by Joule effect.
The thermal images obtained by the ThermaCAM SC 3000 showed a localized warmer zone on the wing upper surface; a comparison with the pressure distribution results and the smoke flow visualizations confirmed that this warmer zone corresponded to the bubble position, confirming that the thermographic investigation is able to visualize boundary layer separation phenomena.

The bubble location and dimensions have been studied for many angles of attack, and for different Reynolds numbers; the bubble position seems strongly influenced by the incidence angle, a reduction of the overall dimensions is shown increasing the angle and the Reynolds number.

Why infrared thermography?

The methods normally used to investigate the presence of a Laminar Separation Bubble are the load balance, the pressure coefficient analysis and the smoke and oil visualization technique. The choice to use infrared thermography is due to the fact that it is a non-intrusive measurement technique and gives a real time visualisation of the phenomena.

According to Professors Ricci and Cesini, the University of Ancona opted for a FLIR Systems ThermaCAM SC 3000 infrared camera system because of its extremely high thermal sensitivity of 0.02°C making it possible to see the slightest temperature differences. Furthermore, combined with the ThermaCAM Researcher HS package, the SC 3000 allows in-depth analysis of real-time images at 750 Hz.
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