EFFECT OF A SPLITTER PLATE IN THE NEAR WAKE OF A DIVERGENT TRAILING EDGE

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A decrease in wave drag can be achieved by thickening the trailing edge of wings equipped with supercritical airfoils and flying at transonic speeds[1], but this gain is partially offset by an increase in base drag. Devices capable of reducing base drag were therefore investigated[2–3]. However, the aerodynamic mechanisms governing their operation are still poorly known. This paper describes a local experimental and numerical analysis of flows from trailing edges both with and without base drag reduction devices based on splitter plates. The difficulty was to take the unsteady 3D nature of the flow into account. This required the use of appropriate experimental and numerical techniques.

EXPERIMENTAL

A model representing a simplified trailing edge was analyzed experimentally in a water tunnel. We attempted to achieve the best possible simulation of the trailing edge flow conditions, and particularly the shear between the upper and lower surfaces and boundary layer thickness. The test section is vertical and square. It has a cross section of 300 mm² and a length of 1 m. It can be equipped with windows to observe the flow over the complete length and in the two directions perpendicular to the upstream velocity. Tests were conducted for Reynolds (Re) numbers below 20,000. These Re numbers were calculated with the upper surface velocity and the trailing edge thickness. The experimental techniques used included Schlieren photography, PIV and measurement of the total unsteady lift and drag loads using a strain gage balance. These techniques were inter-correlated in pairs. Schlieren photography is an optical flow visualization technique based on the deflection of light rays related to a variation in the refraction index of the medium being analyzed. If the fluid is water, the index variations depend on the local temperature gradients. This property was put to use to study separated flows in a water tunnel[4] (Fig.1). Recording simultaneously Schlieren visualizations in the two directions normal to upstream velocity gives access to the 3D structure of the flow. PIV (particle image velocimetry) is a laser technique giving a measurement of the instantaneous velocity field. A number of frames were used to increase the resolution and accuracy in the near wake. Certain plates were analyzed by two different techniques. The first used the intercorrelation principle[5] (Fig.2) and the second used the optical flow method[6]. The purpose was to examine the effects of the analysis on the resolution and accuracy of the measured velocity fields.

NUMERICAL ANALYSIS

From a numerical standpoint, direct numerical simulations (DNS) and large eddy simulations (LES) are performed using two different 3D computation codes. The first used the velocitypressure formulation of the Navier-Stokes equations[7], and the second their velocity vector-eddy vector formulation[8].

RESULTS

The numerical results (Fig.3) were validated by the data from the experiments described above (Figs.1 and 2) in order to simulate correctly the aerodynamic mechanisms governing the base drag reduction induced by the splitter plate.

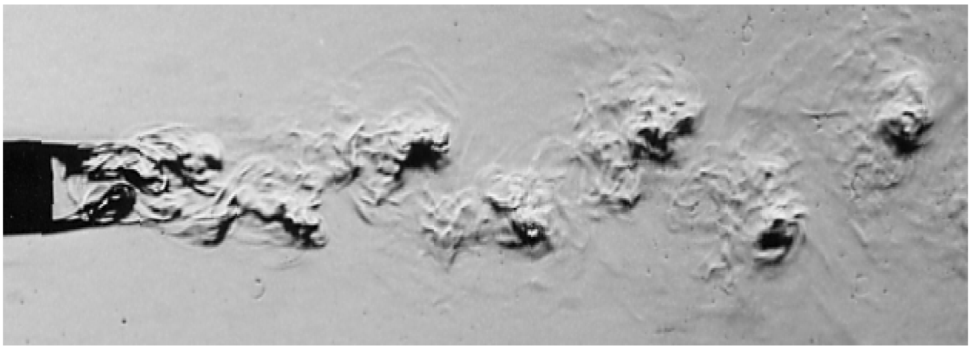

Fig 1: An example of Schlieren visualization

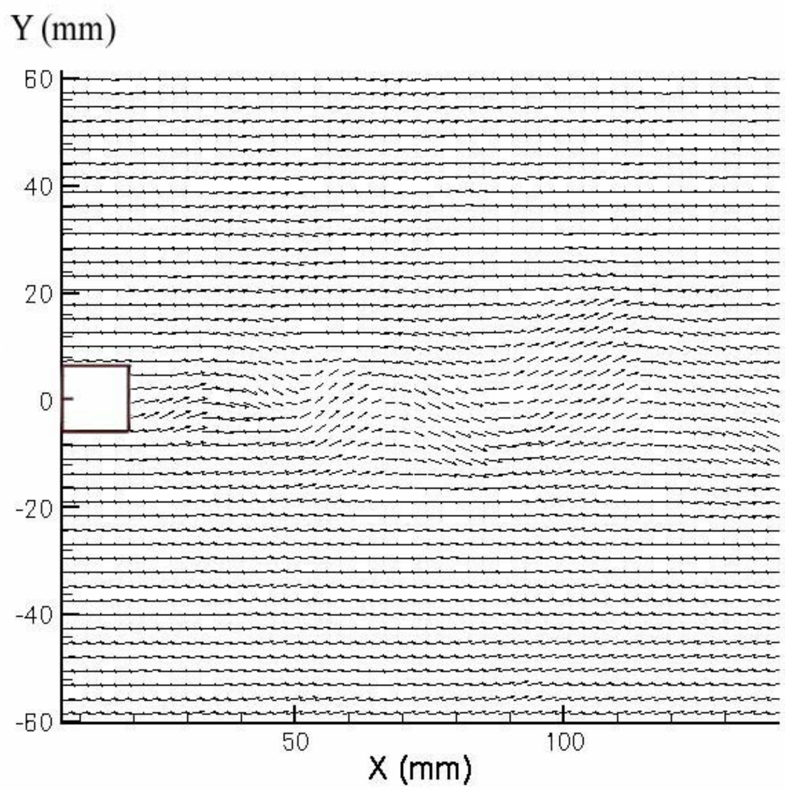

Fig.2: An example of PIV velocity field

REFERENCES

1. HENNE Preston A., GREGG Irvine R.D., New Airfoil Design Concept, J. *Aircraft*- Vol.28 n°5- May 1991

2. RODRIGUEZ O., Amélioration du concept de bord de fuite divergent en transsonique par réduction de la traînée de culot, Novembre 1998, *rapport technique ONERA*

3. RODRIGUEZ O., PRUVOST J., LE ROY J.F., Etude préliminaire de dispositifs destinés à améliorer les performances d'un profil équipé d'un bord de fuite épais, décembre 1996, *contrat SPAé-Etude IMFL* n°94328

4. RODRIGUEZ O., Base drag reduction by control of the three-dimensional unsteady vortical structures, *Experiments in Fluids* Vol 11, pp 218-226, 1991

5. MONNIER J.C., CROISIER G., GILLIOT A., Characterisation of the EUROPIV nozzle by PIV, using a CCD recording device, Particle Image Velocimetry: *Progress towards industrial application*, Kluwer Academic Publishers, pp 226-233, published in 1999

6. Georges M. QUENOT, Jaroslaw PAKLEZA, Tomasz A. KOWALEWSKI, Particle Image Velocimetry using optical flow for image analysis, *8TH Int. Symp. on Flow Visualization*, 1998

7. BREZILLON J., Calculs FLU3M Euler et Navier-Stokes de l'écoulement basse vitesse autour du profil NACA0012, décembre 1998, *rapport technique ONERA*

8. LARDAT Raphaël, Simulations numériques d'écoulements externes instationnaires décollés autour d'une aile avec des modéles de sous-maille, *Thèse de doctorat de l'université Paris 6*, juillet 1997