

Laser-Doppler Measurements of a Highly Curved Flow

by

J.M.M. Barata^{*1}, D.F.G. Durão^{**}, F. Ferrão^{*}, A.R. Silva^{*}, M.A. Silvestre^{*}

^{*}Universidade da Beira Interior
Aerospace Sciences Department
Rua Marquês d'Ávila e Bolama
6201-001 Covilhã, Portugal

¹ (corresponding author) E-mail: jbarata@ubi.pt

^{**}Universidade Lusíada
Rua da Junqueira
1349-001 Lisboa, Portugal
E-mail: d.durao@lisboa.ulusiada.pt

ABSTRACT

Laser-Doppler measurements of the velocity characteristics of a highly curved flow resulting from the collision of a wall jet with a boundary layer are presented and discussed together with visualization results.

Highly curved flows are quite common in nature and are frequently originated by impermeable surfaces that deflect a flow (e.g. Castro and Bradshaw, 1976). Another example is the flow resulting from the impingement of a jet on a flat surface with or without the presence of a crossflow. In this latter case (e.g. Barata and Durão, 2004), the impingement of the jet on the ground results in the formation a wall jet that flows radially from the impinging point along the ground surface. The interaction of this wall jet with the free stream results in the formation of a ground vortex far upstream of the impinging jet. Barata and Durão (2004) found that the shape, size and location of the ground vortex were dependent on the ratio between the jet exit and the crossflow velocities, and two different regimes were identified. One is characterized by the contact between the ground vortex and the impinging jet, while another is detached upstream the impinging zone. They also report that the crossflow acceleration over the ground vortex was directly connected with the jet exit velocity, and the influence of the upstream wall jet was not confined to the ground vortex but spread upwards by a mechanism not very well known yet.

This paper presents a detailed analysis of the highly curved flow resulting from the collision of a wall jet with a boundary layer, and aims to improve the understanding of the ground vortex behaviour. To avoid the influence of the impinging region a plane wall jet is produced independently using a configuration already used to study two-dimensional up wash flows (see Gilbert, 1983). The wall jet collides with the boundary layer produced using a conventional wind tunnel giving rise to a ground vortex, which can be studied for different velocity ratios between the wall jet and crossflow.

The velocity field is measured by a DANTEC *Flow Lite* dual-beam, backscatter laser anemometer with sensitivity to the flow direction provided by light-frequency shifting from acoustic-optic modulation. Turbulent shear stresses are also presented in detail in order to analyse the complicating influences of curvature like extra strain rates.

References

- Castro, I.P. and Bradshaw P. (1976), "The Turbulence Structure of a Highly Curved Mixing Layer". *Journal of Fluid Mechanics*, vol. 73, part 2, pp. 265-304.
- Barata, J.M.M. and Durão, D.F.G. (2004), "Laser-Doppler Measurements of Impinging Jets Through a Crossflow". Accepted for publication in *Experiments in Fluids*.