Experimental observations of trailing vortices at high Reynolds numbers

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Experimental techniques applied to the study of wingtip vortices are of great interest for the Fluid Mechanics Community. The available experimental techniques to obtain new insights into trailing vortices, focus on quantitative methods, e.g. Particle Image Velocimetry (PIV)[1,2]. In fact, this technique requires high costs associated not only to equipments but also to image processing that is a complex, and time consuming task. A novel, easier, faster and cheaper experimental procedure is presented in this research work to compute experimentally the vortex structure in comparison to a theoretical model.

Different theoretical models have described the velocity field for every cross section along the axial coordinate, once the vortex was created at the wing tip. These models depend on several parameters and provide the axial evolution of the velocity field. We used in this study a q-vortex or Batchelor's[3] model, based only on two free parameters: swirl value, q, and the virtual origin in the axial coordinate, z_0. These parameters have been processed with the experimental trailing vortex formed by a NACA0012 aerofoil over a Reynolds number range of 10^5.

The experimental setup consists of one smoke wire device together with a laser beam, and a digital camera installed in a subsonic wind tunnel. A smoke segment was generated upstream the model, but near the wing edge. This line followed the main stream passing through the wing tip. Lift forces produced the characteristic vortex pattern, highlighted by the swirling smoke segment, and whose topological structure was recorded by a digital camera. Several sections at different axial distances from the wing edge have been analyzed. The integration of the velocity field in the theoretical model allowed us to know two theoretical parameters in order to obtain similar experimental streaklines at a given axial position, as shown in figure 1. The experimental results using this procedure were in agreement with those found in the literature[1].

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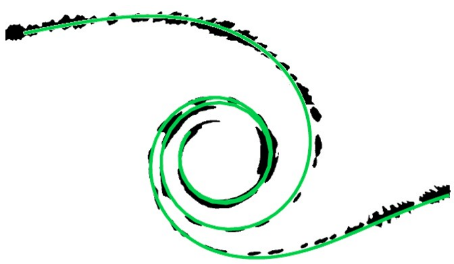

Figure 1: Processed image: Smoke (black) and theoretical streakline (green) for a trailing vortex.