LIFT AND DRAG COEFFICIENTS BEHAVIOUR AT LOW REYNOLDS NUMBER IN AN AIRFOIL WITH GURNEY FLAP SUBMITTED TO A TURBULENT FLOW. PART 1

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Abstract - **Boundary layer wind tunnel experiments have been conducted in order to investigate the influence of a Gurney flap upon the aerodynamic behaviour of an HQ 17 airfoil. The airfoils, with and without the Gurney flap, were submitted to two different turbulent flows with the same mean wind velocity but with different turbulence structures. Lift and drag coefficients were calculated in both cases, then plotted and contrasted with low velocity laminar wind tunnel data of the HQ17 with and without miniflaps Gurney, obtained from Bechert *et al.* (2000) at the DLR, Technical University of Berlin, Germany. The results show that the Gurney flap acts enhancing the lift coefficient of the airfoil, and that its performance is almost independent of the scales of the incoming turbulence. The tests were performed at a turbulence intensity of 1.8% and 3.5% and at a Reynolds number of 3x10^5.**

Keywords – **Flow control – Low Reynolds Number Airfoils – Turbulence – Aerodynamics.**

I. INTRODUCTION

The performance of airfoils operating at low Reynolds numbers has been a topic of increasing attention during the last decades.

This interest was a consequence of a search for improving aircraft low speed performance as well as for improving the design of wind turbine blades (Fuglsang *et al.,* 1999), rotors and propellers.

High-lift aerodynamics continues playing an important role in the design of a new aircraft. Improved high-lift performance can lead to increase range and payload, or decrease landing speed and field length requirements. Hence, there is a continuous need for improving the maximum lift and lift-to-drag ratio, *L/D*. Improved airfoil performance using a small trailing edge flap, was first reported by Liebeck (1980) from tests made on a Newman symmetric airfoil with a Gurney flap, in a non turbulent flow environment. Miniflaps, such as Gurney flaps, are small extensions at the trailing edge of an airfoil perpendicular to its lower surface. Its size is typically 0.5% to 2% of the airfoil chord length. These devices were first used by Dan Gurney, a race car driver, on a racing car wing, resulting in an increase of its maximum speed and its down force in cornering. Later, the Gurney flap was studied by Liebeck (1978). In his tests, Liebeck studied a Gurney flap of 1.25% the wing chord length, observing an increase of the lift and lift-to-drag ratio compared with the same airfoil without the flap. The Gurney flap acts as a mechanism of passive flow control. To explain the drag reduction at high angles of attack, Liebeck presented a model of the flowfield in the region of the Gurney flap, that model has been substantiated by flow visualization tests made in a water tunnel by Neuhart and Pendergraft (1988). The water tunnel tests showed that the presence of the Gurney flap provoked an extension in the region of attached flow on the upper surface of the wing, with a recirculation region behind the flap. This is consistent with a reduced form drag obtained at high lift coefficients using a Gurney flap. Later works confirmed this finding (Bloy and Durrant, 1995; Storms and Jang, 1994).

Selig *et al.* (1996) performed several experimental and computational analyses on low Reynolds number airfoils, in particular, on airfoils with Gurney flaps, disregarding the turbulence of the free stream.

The local velocities seen by a wing section are the result of the vectorial addition of the airplane velocity and the atmospheric velocities. Attitude changes produce lateral or vertical slip, and airplane rotations generating pitching, yawing and rolling moments.

The atmospheric surface layer, in which important flight operations take place, is characterised by complex turbulent flows. These flows are strongly influenced by the terrain roughness elements, like particular topography, suburban and urban areas, different plantations, etc.

The influence of turbulence on the resulting flow patterns around wing sections (airfoils) depends on the relation between airplane mean velocity to atmospheric turbulent velocities, among other factors. The turbulence induced by flow perturbations around an airfoil, influences the occurrence of attached flows, unsteady disordered separated flows and vortex generation. Representative wind tunnel experiments should reproduce the main turbulence characteristics of the regions in which a particular airplane is expected to operate. The