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LIFT AND DRAG COEFFICIENTS BEHAVIOR AT LOW REYNOLDS NUMBER IN AN AIRFOIL WITH MINIFLAPS GURNEY SUBMITTED TO A TURBULENT FLOW. PART 2

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Abstract **– Following the work performed in Part 1, new wind tunnel experiments were conducted in order to investigate the influence of different sizes of Gurney mini-flaps upon the aerodynamic behavior of a low Reynolds number airfoil HQ 17. The airfoil, with and without the Gurney mini-flaps, are immersed in a low Reynolds number turbulent flow. Lift and drag coefficients were calculated for the plain wing and for the wing with mini-flaps of 1%, 1.5%, 2% and 2.5% height of the chord and plotted as a function of the angle of attack (α). The experimental data, including the power density spectrum of the instantaneous longitudinal and vertical velocities and load, show that the Gurney mini-flap acts enhancing the lift coefficient of the airfoil coupled with an increased drag, primarily due to the particular mini-flaps wake structure. We also found that the airfoil performance, for the four mini-flaps tested, is almost independent of the scales of the incoming turbulence.**

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

NOMENCLATURE

C_L = lift force coefficient
C_{Lmax} = maximum lift force coefficient
C_D = drag force coefficient
C_{D0} = parasite drag force coefficient
D = measured drag force [N]
E_{max}, = maximum efficiency
F = frecuency [Hertz]
H = Gurney miniflap height
L = measured lift force [N]
S = wing section surface [m^2]
$S(f)$ = Power Density Spectra Distribution [m^2/s]
Str = Strouhal number
U = mean longitudinal velocity [m/s]
V = mean vertical velocity [m/s]
α = angle of attack [degrees]
ρ = density [Kg/m^3]

I. INTRODUCTION

The authors presented in Part 1 an extended introduction regarding the use of Gurney mini-flaps of different sizes as passive flow control devices (Colman *et al.,* 2008).

The purpose of this Part 2 is to extend the research work started by the authors in Part 1, for another mini-flaps sizes, with the aim to contribute to a better understanding of the effect of the incoming turbulent flow and mini-flaps sizes, upon the behavior of the lift and drag coefficients of a low Reynolds number airfoil HQ17. In this part were tested Gurney mini-flaps of 1%, 1.5%, 2% and 2.5% height (H) of the wing chord (see Fig. 1). The chosen sizes of the mini-flaps employed in the present work and in our previous work, are in agreement with other authors, like Schatz *et al.* (2004), Bechert *et al.* (2000), Thiele *et al.* (2007) Bloy and Durant (1995) and Bloy *et al.* (1997). For mini-flaps sizes larger than 2.5% the lift increment continuous to rise, but the drag increment is even bigger, producing decrement in the airfoil performance (Liebeck, 1978; Katz and Largmann, 1989). Those authors state that for mini-flap sizes larger than the boundary layer thickness (in our case less than 2% of the airfoil chord) the drag starts to increase considerably, producing an airfoil´s efficiency reduction. Also, they found maximum airfoil efficiency for mini-flap sizes from 1.3% to 2%, depending on the incident flow and the baseline airfoil.

Troolin *et al.* (2006) report that the boundary layer thickness, in the trailing edge, is around 2% of the airfoil chord. Because of that we used mini-flap sizes up to 2.5%.

The mini-flap acts increasing the circulation around the airfoil by shifting the Kutta condition below the airfoil´s sharp trailing edge, as we explained previously (Colman *et al.,* 2008). Troolin *et al.* (2006), also, report that using PIV techniques, the vortex street shedding had a frequency representing Strouhal numbers from 0.13 to 0.18.

Flow control involves passive and active devices that produce desirable changes on the near walls flows and/or free shear flows (Gad-el-Hak, 1998; 2001). Passive systems, unlike active ones, do not require extra energy (Lachmann, 1961).

Flow control main objectives are: to delay or move forward the turbulent transition zone, to eliminate or increase turbulence, to prevent or to promote boundary layer separation, in order to reduce the aerodynamic drag, to increase the lift force, to improve flow mixture and to induce noise reduction, all by fluid dynamics methods (Ekaterinaris, 2004).