EXPERIMENTAL DETERMINATION OF THE INFLUENCE OF TURBULENT SCALE ON THE LIFT AND DRAG COEFFICIENTS OF LOW REYNOLDS NUMBER AIRFOILS

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Abstract— **Boundary layer wind tunnel experiments have been conducted in order to expose aspects of a turbulence scale dependent behaviour of two low Reynolds number airfoils: – Selig 4083 and Selig-Donovan 7037. The airfoils were submitted to two different turbulent flows with the same mean velocity but different turbulence structures. In one of the flows large eddies prevail while the other flow was primarily shaped by small scale eddies. Lift and drag coefficients were calculated and plotted. These values were contrasted with laminar flow wind tunnel data obtained from previous experiments made at the University of Illinois, at Urbana Champaign, by the Experimental Aerodynamic Group led by Michael Selig.**

Keywords— **Aerodynamics -Turbulence – Low Reynolds Number Airfoils**

I. INTRODUCTION

The performance of airfoils operating at low speeds and particularly low Reynolds airfoils has been a topic of increasing attention during the last decade. This interest was a consequence of a search for improving aircraft low speed performance as well as to improve the design of wind turbine blades, jet engine fan blades, rotors, and propellers.

The atmospheric surface layer in which important flight operations take place is characterized by very different, complex instantaneous local wind profiles with strong gusts. These intricate velocity flows are usually originated by wind deviations and eddies produced by the interaction of the natural wind with plants, topographic features, and constructions. Particular air density variations due to temperature and humidity distributions causing unstable thermal stratification, can also trigger the generation of violent gusts. The majority of the previous experimental studies on airfoils were concentrated on boundary layer aspects and the lift and drag outcome, disregarding the analysis of the turbulent structure of the oncoming flow, the wake flow structure and the evolution of vortex shedding processes.

The local velocities felt by a wing section are a result of the vectorial addition of the airplane velocity with the mentioned atmospheric velocities and attitude changes producing lateral or vertical slip, and airplane rotations generating pitching, yawing, and rolling motions.

The influence of turbulence on the resulting flow patterns around wing sections depends among other factors, on the relation between airplane mean velocity to atmospheric turbulent velocities.

The slower an airplane flights the larger will be the instantaneous incident wind directional and intensity variations due to turbulent gusts. The turbulence induced 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 turbulent characteristics of the regions in which a particular airplane is expected to operate.

Stack (1931) performed one of the first experiments investigating effects of scale and turbulence in 1931, at the NASA-Langley Memorial Aeronautical Laboratory. Turbulence was generated by suitable grids. Unfortunately at that time the scale and intensity of turbulence were not measured due to the inexistence of reliable instruments. Over the years, the experimental study of turbulent structure effects on airfoil characteristics was scarce.

General aspects of the scenario involving dynamic separation and reattachment on airfoils have been treated by Green and Galbraith (1996).

Turbulent gusts as well as fast pitching motions can generate rapid angle of attack variations. With adequate caution, some oscillating airfoil experimental information may be applied to reveal aspects of the aerodynamics of non pitching wings in a turbulent flow environment.

As far as the authors know most of the previous experimental studies about oscillating airfoils as those performed by (e.g. Carr *et al.*, 1977; Leishman, 1990), were concentrated on pitching airfoils disregarding the influence of turbulent scale in the oncoming flow.

Studies of an airfoil submitted to oscillating and translating motion in low Reynolds number conditions were presented by Ohmi *et al.* (1990 and 1991).

Fluctuating angle of attack of the oncoming velocity can promote the beginning of localized airfoil stall fol-