

ABOUT THE TURBULENT SCALE DEPENDENT RESPONSE OF REFLEXED AIRFOILS

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Abstract— Boundary layer wind tunnel experiments have been conducted to explore differences in the aerodynamic behavior of two autostable or reflexed airfoils, with different positive camber submitted to three different incoming flows with the same mean velocity but with different turbulence characteristics.

The variations of lift and drag coefficients due to the path of turbulent structures with different scales are presented.

The experiments were performed at a mean speed of 10 m/sec, corresponding to a Reynolds Number of 205000.

Keywords— Aerodynamics -Turbulence - Low Reynolds Number Airfoils

I. INTRODUCTION

Standard airfoil data is typically described in terms of steady mean velocities, without a characterization of the turbulent eddies immersed in the natural wind (Bertin and Smith, 1998).

Very different instantaneous local winds with varying incidence and strength act on a wing flying at low height through the atmospheric surface layer.

These velocity fluctuations are caused by the different flow patterns of passing eddies with diverse shapes, dimensions and intensities, embedded in the atmosphere (Hinze, 1975).

These vortex structures are induced by the flow deviations, and velocity variations induced by plants, buildings, different soil roughness, topographic features, density, and temperature gradients.

When a turbulent structure interacts with a wing, flying at constant velocity and angle of attack, the flow becomes nonstationary originating an unsteady pressure field around the wing generating fluctuant lift and drag as well as broadband noise.

The instantaneous angle of attack variations generated by a passing eddy may produce upwash, downwash, stream aligned forward, backward and

transversal fluctuations causing unsteady lift and drag. It seems reasonable to conjecture that the aerodynamic forces on a wing submitted to turbulence with prevailing large-scale eddies, behave different from those corresponding to the effects of small scale eddies.

Since nearly 1930, the interaction of turbulence with lifting airfoils has involved important aerodynamic research. Early studies began considering thin plates as airfoils embedded in steady irrotational incompressible flow. Sears (1941) analyzed the unsteady lift and moment of ideal thin flat plates with no angle of attack, flying through irrotational flow at constant velocity submitted to an oncoming sinusoidal vortical perturbation altering the velocity field.

The sinusoidal perturbation used by Sears could be interpreted as an early approach to turbulent structure pattern consideration.

Liepmann (1955) developed a technique considering the frequency spectrum of the incoming turbulence, and Ribner (1956) improved the methodology by including the complete three dimensional turbulence spectrum.

Further research included thickness effects like stagnation point wandering due to turbulence induced angle of attack variations (Morfe, 1970).

McKeough and Graham (1980) considered the distortion effects of a passing turbulent eddy due to the flow pattern of an airfoil by means of the rapid distortion theory.

McKeough and Graham (1980) performed experiments on a NACA 0015 airfoil submitted to grid generated turbulence, measuring the fluctuating lift.

Scott and Atassi (1995) presented a numerical simulation for subsonic flows, with convected three-dimensional gusts.

Despite the different theories about the interaction of turbulence with wings, the experimental research about this issue was infrequent.

II. METHODS

The objectives of the present experiments were concentrated in getting experimental aerodynamic data