World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:10, No:08, 2016

# Effects of Prescribed Surface Perturbation on NACA 0012 at Low Reynolds Number

**Authors :** Diego F. Camacho, Cristian J. Mejia, Carlos Duque-Daza

**Abstract :** The recent widespread use of Unmanned Aerial Vehicles (UAVs) has fueled a renewed interest in efficiency and performance of airfoils, particularly for applications at low and moderate Reynolds numbers, typical of this kind of vehicles. Most of previous efforts in the aeronautical industry, regarding aerodynamic efficiency, had been focused on high Reynolds numbers applications, typical of commercial airliners and large size aircrafts. However, in order to increase the levels of efficiency and to boost the performance of these UAV, it is necessary to explore new alternatives in terms of airfoil design and application of drag reduction techniques. The objective of the present work is to carry out the analysis and comparison of performance levels between a standard NACA0012 profile against another one featuring a wall protuberance or surface perturbation. A computational model, based on the finite volume method, is employed to evaluate the effect of the presence of geometrical distortions on the wall. The performance evaluation is achieved in terms of variations of drag and lift coefficients for the given profile. In particular, the aerodynamic performance of the new design, i.e. the airfoil with a surface perturbation, is examined under conditions of incompressible and subsonic flow in transient state. The perturbation considered is a shaped protrusion prescribed as a small surface deformation on the top wall of the aerodynamic profile. The ultimate goal by including such a controlled smooth artificial roughness was to alter the turbulent boundary layer. It is shown in the present work that such a modification has a dramatic impact on the aerodynamic characteristics of the airfoil, and if properly adjusted, in a positive way. The computational model was implemented using the unstructured, FVM-based open source C++ platform OpenFOAM. A number of numerical experiments were carried out at Reynolds number 5x104, based on the length of the chord and the free-stream velocity, and angles of attack 6° and 12°. A Large Eddy Simulation (LES) approach was used, together with the dynamic Smagorinsky approach as subgrid scale (SGS) model, in order to account for the effect of the small turbulent scales. The impact of the surface perturbation on the performance of the airfoil is judged in terms of changes in the drag and lift coefficients, as well as in terms of alterations of the main characteristics of the turbulent boundary layer on the upper wall. A dramatic change in the whole performance can be appreciated, including an arguably large level of lift-to-drag coefficient ratio increase for all angles and a size reduction of laminar separation bubble (LSB) for a twelve-angle-of-attack.

**Keywords :** CFD, LES, Lift-to-drag ratio, LSB, NACA 0012 airfoil
**Conference Title :** ICAMAME 2016 : International Conference on Aerospace, Mechanical, Automotive and Materials Engineering
**Conference Location :** Barcelona, Spain
**Conference Dates :** August 11-12, 2016