

Aerodynamic Study of Boeing 747-400 Airfoil

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Abstract– After a long history of human kind, new means of transportation evolved such as trains, cars, and airplanes. Definitely, after the Second World War, Airplanes became more commonly used for both commercial and military sectors because of its high speed and reliability. For a successful flight, sufficient lift force should be exerted on the airplane body. Thus, the most important thing is the wing cross section; for which the Bernoulli principle is applied “the pressure decreases as the velocity increases and vice versa”. Hence, a computational model was developed to compute the forces exerted on the airfoil such as drag, and lift using SolidWorks and ANSYS-Fluent software.

Keywords– CFD, Boeing 747-400 Airfoil, Lift force, Drag force, Spalart-Allmaras model.

1. INTRODUCTION

The main objective of this paper is a computational fluid dynamic (CFD) study of the flow behavior over BOEING 747-400 airfoil “BACX00” by using SolidWorks and ANSYS-Fluent software.

Computational fluid dynamics (CFD) is a numerical method based on computer programming in which all the governing equations are approximated to find efficient results by averaging them. CFD graphics-interface is a good technique to demonstrate the accurate formation of the behavior that can happen in an experimental wind tunnel setup. CFD results are directly analogous to wind tunnel results obtained in a laboratory. They both represent sets of data for given flow configurations at different Mach numbers, Reynolds numbers, etc. However, unlike a wind tunnel, which is generally a heavy, unreluctant device, a computer program is something you can carry around in your hand. Or better yet, a source program in the memory of a given computer can be accessed remotely by people on terminals that can be thousands of miles away from the computer itself. A computer program is, therefore, a readily transportable tool, a “transportable wind tunnel.” [1].

11. PRESENT MODEL

SolidWorks [2] and ANSYS-Fluent [3] software were used for graphics and computational analysis, respectively.

The Boing airfoil BACX00 has maximum thickness of 11.3% at 35% of chord and maximum chamber of 1.4% at 15% of chord [4]. Figure 1 illustrates the nomenclature of the airfoil. Table 1 shows the nomenclature of airfoil and related properties. The present study was carried out at different

values of the angle of attack (α) equal to 2°, 6°, and 8°. For α equals to 2°, 6°, and 8°, Mach number (M) was taken as 0.24 near ground surface, pressure far-field boundary condition was used with Spalart-Allmaras model as the turbulence model.

Moreover, the present study covers the aerodynamic behavior at 9,000 m with other values of Mach numbers “cruising speed” of 0.65, 0.7, and 0.85 using the same boundary conditions and turbulence model. The chord length of the airfoil, that equals 14.6304 m, was taken at the root of the wing (at the airplane fuselage). Temperature was kept at 288 K.

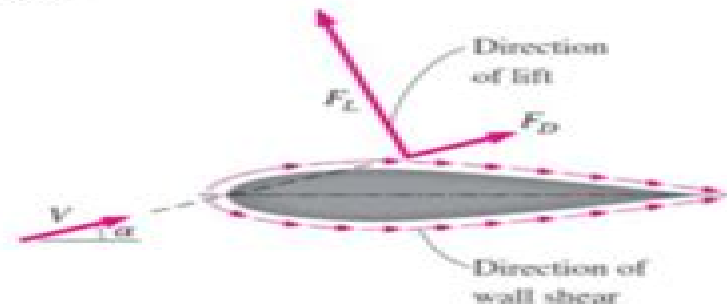


Fig. 1 The nomenclature of the airfoil [5].

Table 1. Nomenclature of airfoil and related properties.

Symbol	Description
α	Angle of attack of the wings [°]
M	MACH number
C_L	Lift coefficient
C_D	Drag coefficient
C_m	Pitching Moment Coefficient
C_p	Pressure coefficient
F_L	Lift force
F_D	Drag force
P_0	Total pressure [Pa]
T_0	Total temperature [K]
V	Cruising speed of the airplane [m/s]
l	Chord length of airfoil cross section [m]
ν	Kinematic viscosity of the air (m ² /s)

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