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Brief Report

Analysis of Stepped Airfoil by Comparing with the Conventional NACA4415 Airfoil

Nagesh Devareddy*, Deepa MS, Hari Krishna S, Anushree N, Bhavana A J, Monika Chavan A

Department of Aeronautical Engineering, S J C Institute of Technology, Chickballapur, India

ABSTRACT

Stepped airfoils offer certain advantages over conventional airfoil. This work was aimed to investigate the performance of stepped airfoils at low speed to explore the potential applications of such airfoils in Unmanned Aerial Vehicles (UAV). The flow is defined as two dimensional, incompressible, laminar, unsteady flows. Aerodynamic performance characteristics were studied by comparing the experimental results with previous studies related to stepped airfoils. The Ansys fluent is a modeling tool and simulation tool for two dimensional stepped airfoils. At first, NACA4415 airfoil is analyzed at low Reynolds number. Later, the stepped airfoil is analyzed at same boundary conditions. Thus the effect of step on the aerodynamic characteristics of an airfoil can be known and if the newly designed stepped airfoil generates more lift and less drag compare to conventional airfoil, then the step on airfoil helps in preventing the flow separation. This result has more advantages in the modern aviation and can be explored to the application of stepped airfoil in UAVs.

Keywords: UAVs; Stepped airfoil; Lift; Drag; Ansys

INTRODUCTION

Unmanned aerial vehicles

Automated aerial vehicles are the airplanes with practically no human pilot, group or travelers ready. UAVs are a part of an automated airplane framework (UAS), which incorporates adding a ground-based regulator and an arrangement of interchanges with the UAV. The trip of UAVs might work under controller by a human administrator. They may be remotely-guided airplane or up to completely independent airplane that have no arrangement for human mediation. Today, UAVs had turned into a fundamental resource for most militaries. As control advances improved and costs fell, their utilization extended to numerous non-military applications. These incorporate woods fire checking, airborne photography, item conveyances, agribusiness, policing and reconnaissance, framework reviews, science and robot hustling. They are basic for different applications where human mediation is unthinkable, hazardous or costly. The created forms of UAVs are by and by utilized drones [1].

Stepped airfoil

Ventured airfoils offer specific benefits over traditional airfoil. This work was planned to examine the presentation of ventured airfoils at low speed to investigate the expected utilizations of such airfoils in UAVs. The stream is characterized as two layered, incompressible, laminar, flimsy streams. Streamlined execution attributes were concentrated by contrasting the trial results and past investigations connected with ventured airfoils. The Ansys fluent is a demonstrating instrument and reproduction device for two layered ventured airfoils. Right away, NACA4415 airfoil is examined at low Reynolds number [2]. Afterward, the ventured airfoil is broke down at same limit conditions. In this way the impact of step on the streamlined qualities of an airfoil can be known and assuming the recently planned ventured airfoil produces more lift and less drag contrast with traditional airfoil, then, at that point, the step on airfoil helps in forestalling the stream partition [3]. This outcome enjoys more benefits in the advanced flight and can be investigated to the use of ventured airfoil in UAVs as shown in Figure 1.

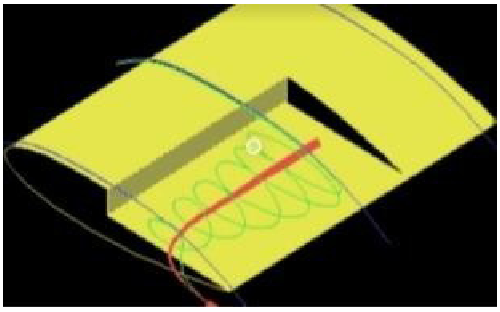

Figure 1: Stepped airfoil of automated aerial vehicles.

Correspondence to: Nagesh Devareddy, Department of Aeronautical Engineering, S J C Institute of Technology, Chickballapur, India, E-mail: nageme417@gmail.com

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Objectives

- Geometric modeling of NACA4415 airfoil and stepped airfoils using Ansys software.
- Investigating the lift and drag characteristics of airfoil with backward facing step on upper surface at mid chord.
- Analysis and comparison of the characteristic parameters between the conventional NACA4415 airfoil and its modified form.

MATERIALS AND METHODS

Predetermining the project and market survey.

Literature survey: understanding and implementing the ideas.

Comparing all the designs that were made by previous authors and find the airfoil that can be modified.

Modeling of NACA4415 airfoil and upper surface stepped airfoil in Ansys using coordinates.

Meshing of airfoils is done in Ansys and applied the suitable flow filed characteristics (boundary condition).

Flow over the airfoils is analyzed for different angles of attack and obtained the results of pressure and velocity contours along with lift and drag co-efficient.

Softwares used

Ansys 18.1 is a finite element analysis software used for simulating engineering problems, enabling product testing and optimization.

Ansys 18.1: Ansys was discovered by John Swanson in 1970. In 1993 he sold his stake in the company to a venture capitalist. Ansys was published on NASDAQ in 1996. Ansys develops and sells finite element analysis software for simulating engineering problems. The software creates simulated computer models of structures, electrical devices, or mechanical components to simulate strength, toughness, elasticity, temperature distribution, electromagnetism, fluid flow, and other attributes [4,5].

Ansys is used to determine how a product works with different specifications without creating a test product or performing a crash test. For example, Ansys software is better than how the bridge will last after years of traffic, how salmon will be processed in a canning factory to reduce waste, without sacrificing safety. You can simulate how to design a slide that uses less material [6].

Numerical modeling and analysis

There are a few parameters which can influence the stream field around an airfoil. Both the airfoil and step profile establish the geometric parameters. The most important ones are the state of an airfoil (symmetric or cambered); harmony length, which was taken as 100 cm; its length and profundity on the upper surface [7,8].

Pre-processing: Geometry of NACA4415 airfoil and Stepped airfoil is modeled by using coordinates.

Meshing: The geometry model was subjected to discretization along with the domain to simulate and analyze the flow over the surface of both the airfoils as shown in Figures 2 and 3.

Post-processing: The post-processing section presents boundary conditions as shown in Table 1.

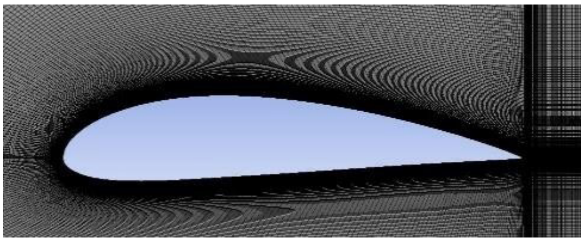

Figure 2: Mesh on surface of NACA4415 airfoil.

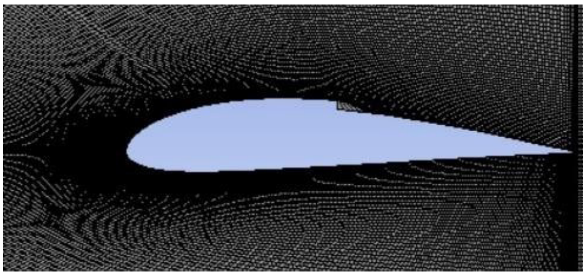

Figure 3: Mesh on upper surface stepped airfoil.

Table 1: Post processing boundary conditions.

Parameters	Selected input
CFD solver	Density based
Energy equation	On
Density	Ideal gas
Viscosity	Sutherland
Viscous model	k-omega-SST
Velocity inlet	10 m/s
Outlet	Pressure outlet
Initialization	Standard
Contours	Pressure and velocity
Plots	Co-efficient of lift and drag

RESULTS AND DISCUSSION

NACA4415 Airfoil

The NACA4415 airfoil is tested for various angles of attack and obtained different contours for pressure and velocity and also obtained the co-efficient of lift and drag. From the analysis it is observed that maximum performance of NACA4415 airfoil is seen between 50 and 100 AOA as shown in Table 2 and Figures 4 a-d.

Table 2: The NACA4415 airfoil at various angles of attack and co-efficient of lift and drag.

AOA	C_L	C_D	C_L/C_D
0	0.35	0.01	23.22
5	0.81	0.02	38.68
10	1.16	0.03	33.69
20	0.95	0.16	5.89

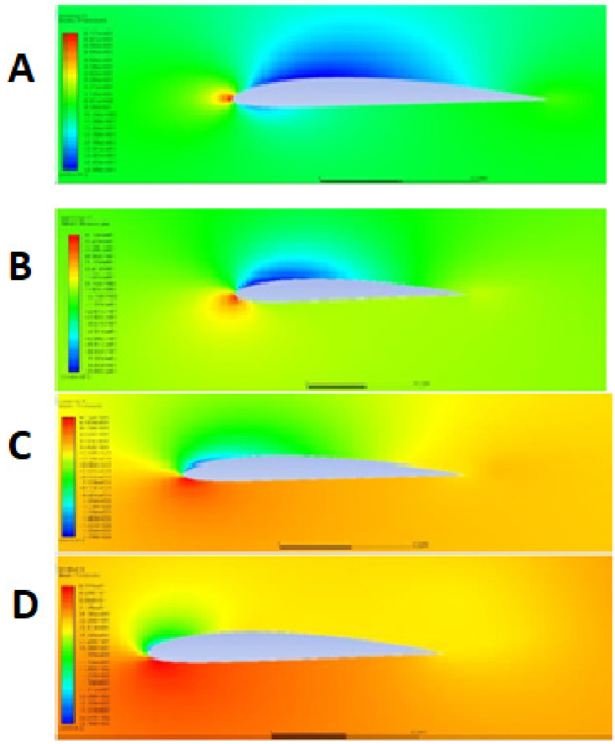

Figure 4: Pressure contours for NACA4415 airfoil at (a): 0°; (b): 5°; (c): 10°; (d): 20°.

Upper surface stepped airfoil

The upper surface step profile is tested for various angles of attack and obtained different contours for pressure and velocity and also obtained the co-efficient of lift and drag as shown in Table 3 and Figure 5 a-d. From the analysis it is observed that maximum performance of this airfoil is at 50 and 100 AOA as shown in Figures 6.

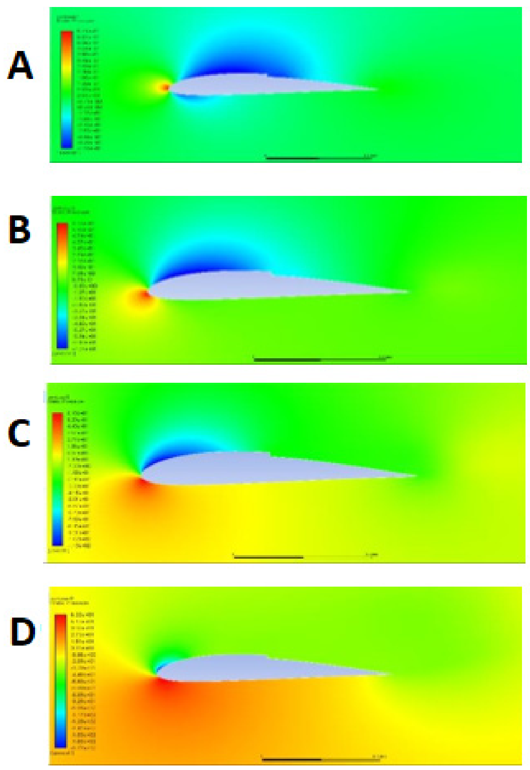

Figure 5: Pressure contours for upper step profile at (a): 0° AOA; (b): 5° AOA; (c): 10° AOA; (d): 20° AOA.

Table 3: Upper surface step profile at various angles of attack and co-efficient of lift and drag.

AOA	C_L	C_D	C_L/C_D
0	0.26	0.02	9.81
5	0.66	0.04	15.86
10	0.86	0.06	13.31
20	0.82	0.19	4.16

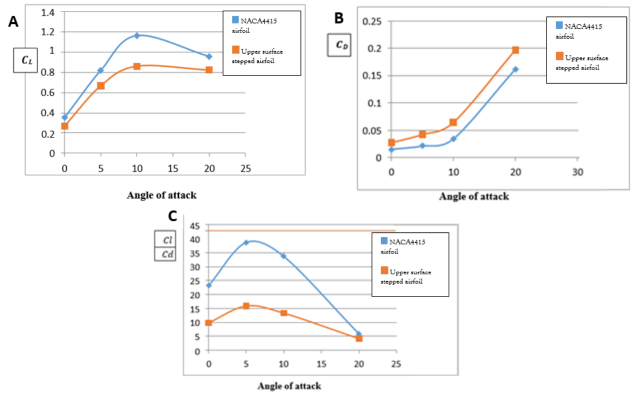

Figure 6: Comparison of NACA4415 airfoil and upper surface stepped airfoil at different AOA. Note: (a): Lift co-efficient; (b): Drag co-efficient; (c): C_l/C_d.

CONCLUSION

This project expected to foster an airfoil which ought to produce lift at low angle of attack. This undertaking objective is to enhance the ventured airfoil with step at various harmony of the NACA4415 airfoil which is standard airfoil and upgraded into a ventured airfoil. Mathematical examination was led by involving Ansys fluent for stream investigation. This mathematical examination gave the aftereffects of C_l and C_d which has been organized. From the examination, NACA4415 airfoil is found to create more lift and less drag contrast with that of upper surface ventured airfoil. Subsequently, it very well may be inferred that NACA4415 airfoil shows great streamlined execution than the upper surface step profile.

FUTURE SCOPE

Airfoils can be modified further by changing the step location on the chord as well as the surface.

According to the literature survey, lower surface stepped airfoils can generate more lift compare to that of upper surface stepped airfoils. So, investigation of lower step profiles can be done.

If the results for lower step airfoils find to produce more lift, then the implementation of the project on real aircraft would really benefit aviation industry in many aspects and would bring the aviation industry to the moto of reducing the noise generation.

Reduced landing and take-off distance will reduce the fuel usage by enhancing the aerodynamic performance of conventional aircrafts by surface modifications.

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