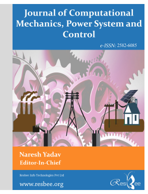
Vol.5 No.2 April 2022

Journal of Computational Mechanics, Power System and Control

Received 23 December, Revised 2 February, Accepted 10 March



Flow Topology of a NACA 0012 Wing Section using Serration Trailing Edge

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Abstract: This research is apprehensive with the aim of the flow topology of a modified serrated wing at the trailing edge. The enhancement is done on a NACA 0012 base wing. CAE software is used to design the model and the same is anatomized using CFD simulation. The simulation is carried out to increase pressure variation along the span of the modified serrated wing. The steady aerodynamic force coefficients that is the lift coefficients and the drag coefficients have been measured over an extensive angles of attack range. Regarding the aircraft wing section performance analysis, the drag and lift coefficients plays an important role. The effect of trailing edge serration with pressure variation on the aerodynamic characteristics of the wing is the most important focal point of this study. Simulations were done for various wing models having different serrations namely 8 serrations, 10 serrations, and 20 serrations. The result proves to give a better lift coefficient and aerodynamic characteristics compared to a wing without serrations. The optimized wing model is chosen by a comparative study between all the simulations with different serrations

Keywords: Aerodynamic, CFD, grid, serration, static pressure

1. Introduction

An airfoil is the cross-section of the wing that, when moved through a fluid produces an aerodynamic force. The component of this force perpendicular to the direction of motion is called lift. The component parallel to the direction of motion is called drag. When either is positive, the resulting flow field about the airfoil has a higher average velocity on the upper surface than on the lower surface. This velocity difference is necessarily accompanied by a pressure difference (via Bernoulli's principle) which in turn produces lift force. Some of the research for the study of the serrated trailing edge is as follows. [1] Carlos Arce Leon, the Study is complimented with acoustic measurements in serrated trailing edge effectively reduces the turbulent boundary layer trailing edges the airfoil noise to a smaller amount than suggestion predicted. [2] Rahul Agarwal, the study of the aerodynamic performance of a wing section with trailing edge modification in the form of saw tooth serrations at lower Reynolds number. [3] Andreas Fischer, the trailing edge serration has been used for the reduction of the emitted sound from an airfoil. The noise reduction became less when the angle of attack increased. At very high angles of attack, the sound was increased. It yields higher noise reductions when compared to the straight edge. [4]Phillip Joseph the experimental study was explained aspired at reviewing how the laminar separation bubble close to the pressure side trailing edge, as well as subsequently the radiation of instability noise, might be manipulated by developing trailing edge serrations without changing the levels of the stream-wise pressure gradient. [5] Angela Marie Knepper, the study was conducted on a modified flat plate with 10mm or 20mm at a single slotted flap. [6]Avallone, the three-dimensional flow field over the suction side of a NACA 0018 airfoil the trailing-edge serrations boundary layer thickness decreases along the streamwise direction depending upon the reduction of the size of the turbulent structures developing over suction side of the serrations. 60deg triangular serration at trailing edge investigation showed that boundary layer developed and improved the aerodynamic characteristics over an aft positioned simply

https://doi.org/10.46253/jcmps.v5i2.a5

2. Methodology

The idea is described by designing the serrations placed usually at some angles. The methodology is based on studying the aerodynamic characteristics of the aircraft with and without serrations thereby optimizing the design. The study is done by using simulation tools as well as by an experimental analysis. The optimization is done by comparing the results with the initial configuration and the pressure variation. The design is generated using CATIA modelling software. The created model is to be analyzed in ANSYS WORKBENCH 16.0 and the model is imported in FLUENT for meshing from that we obtained the required result

Criteria

- To design of NACA0012 airfoil with a wingspan of 4m
- To design the serration at trailing edge of aircraft section
- Analyse the pressure variation for various serration design

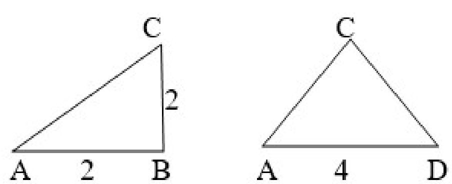
1. 20 serrations at an angle of 64 degree
2. 10 serrations at an angle of 45 degree
3. 8 serrations at an angle of 39 degree

- Comparative study of pressure variation, thereby optimizing the design.

3. Geometry Generation

The geometry is designed in CATIA V5 software it is one of the leading software, it has developed much more than CAD software. It is a solid modelling which has good interconnectivity with many grid generation systems, and avoids the interface problems outlined by Kellar regarding the methods previously used by CAD programs.

Serration Design: The serration design procedure involves the sizing of a serration which depends upon the angle, base and height of a triangle. It is attached on the trailing edge of a wing. The serrated angle, base, height has been modified to study the pressure difference of a wing. It is used to increase the aerodynamics characteristics of lift in an airfoil.
Calculation of 10 Serrations along wing



AC2 = AB2 + BC2
= 4+4
AC= 2.828
Sin A = Opp = 2
Hyp 2.828
A = 45 degree

Table 1: Angle of serration

case	No of serration	Inner Angle (degree)
1	20	64
2	10	45
3	8	38

4. CFD METHODOLOGY

The NACA 0012 is symmetrical, theoretical lift at zero angle of attack. In order to validate the present simulation process, the operating conditions are minimized to match the operating conditions NASA. Reynolds number for the simulated, for free stream velocity at 80m/s. The density of air for the temperature is $\rho = 1.225 kg/m^3$ and the viscosity is 1.7894×10^{-5}kg/ms. Flow for this Reynolds number can be labelled as laminar. A segregated, implicit solver, ANSYS Fluent 16, is utilized to simulate the problem

Boundary Condition: In Computational Fluid Dynamics problem, we need to specified boundary conditions. Boundary conditions are necessary module of a mathematical approach. They direct the flow motion that tends to a exclusive solution. The standard boundary conditions like outlet, inlet, wall, symmetry are used to solve the problems. Velocity Inlet: The inlet velocity is 80m/s and it is specified at normal inlet plane. Pressure Outlet: The outlet pressure is 101.325 Pa which is an ambient pressure, and which is specified atnormal outlet plane. Symmetry boundary condition is used to reduce computational effort in issue. Here, flow field and geometry is symmetric. The velocity is zero at symmetry plane.

Grid Generation: Grid generation around the model is generated by means of unstructured grid. User have to set the domain with respect to mach no, flow condition, and other computational operating condition. The no. of cell in each face is also specified. No. of cells in each case is tabulated. The grids were made very fine at the surface and coarse as it goes away from the body. The wall boundary condition is assigned for the model surface. The meshed models are shown in the below Figures.

Table 2: Parameters of grid generation

Case	i	ii	iii	iv
No.of mesh element	1024328	1350628	349544	909198
No.of nodes	261601	312323	106921	223324
Orthogonal quality	0.98	0.97	0.99	0.99
Maximum aspect ratio	0.90	0.98	1.0	1.01

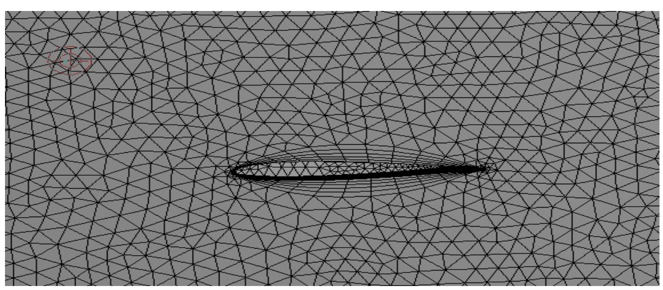


Fig. 1. *Meshed Region*

5. Result and Validation

5.1 Contours of Static pressure over NACA 0012 Airfoil without serration

The contours of static pressure over an aerofoil is symmetrical for above and lower sections. The stagnation pressure is exactly found to be formed at the nose of an aerofoil.

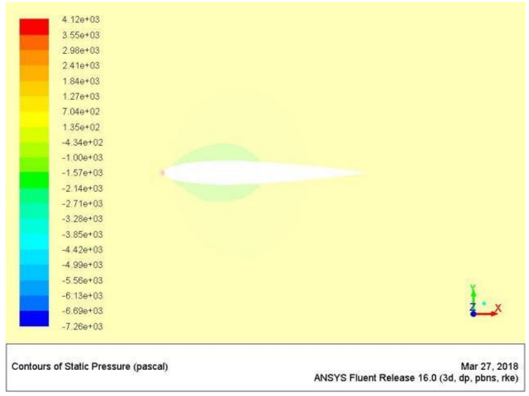


Fig.2. *Contours of static pressure over NACA 0012 airfoil without serration*

5.2 Contours of Static pressure over NACA 0012 Airfoil with 8 serrations

The flow over an aerofoil NACA 0012 with 8 serration indicates that at the leading edge the stagnation pressure is higher and thus the pressure variation along the aerofoil is equalised at the quater chord of an aerofoil thereby reaches the freestream velocity at the trailing edge of an aerofoil .It is found that the pressure varaition along the aerofoil is slightly greater than without serration aerofoil.

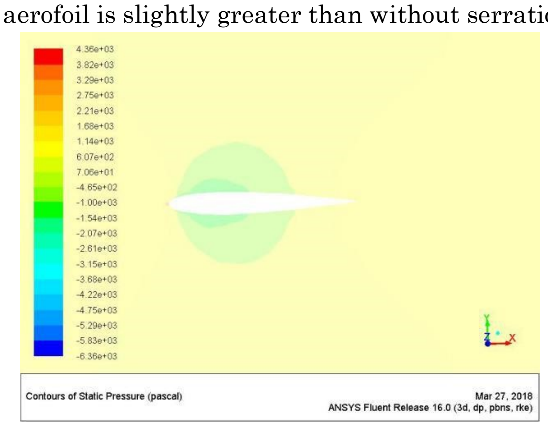


Fig.3. *Contours of static pressure over NACA 0012 airfoil 8 serrations*

5.3 Contours of Static pressure over NACA 0012 Airfoil with 10 serrations

The flow over an aerofoil NACA 0012 with 8 serration indicates that at the leading edge the stagnation pressure is higher and thus the pressure variation along the aerofoil is equalised at the mid chord of an aerofoil thereby reaches the freestream velocity at the trailing edge of an aerofoil. It is found that the pressure varaition along the aerofoil is higher than without serration aerofoil, when compared to without serration of an aerofoil genearates more lift.

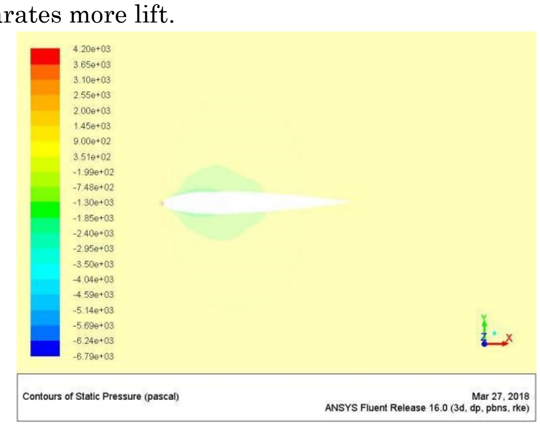


Fig.4. *Contours of static pressure over NACA 0012 airfoil with 10 serrations*

5.4 Contours of Static pressure over NACA 0012 Airfoil with 20 serrations

The flow over an aerofoil NACA 0012 with 20 serration indicates that at the leading edge the stagnation pressure is higher and thus the pressure variation is more along the aerofoil is equalised at the quater chord of an aerofoil thereby reaches the freestream velocity at the trailing edge of an aerofoil .It is found that the pressure varaition along the aerofoil is slightly greater than without serration aerofoil, lower than 10 serration aerofoil.

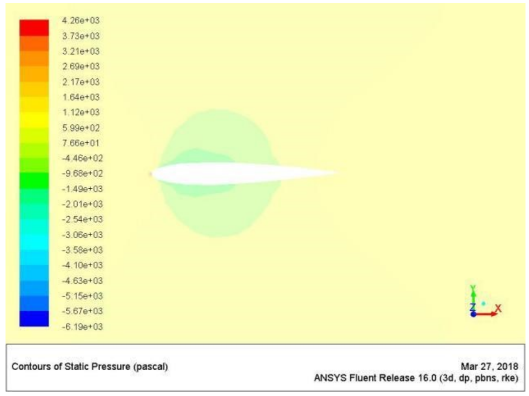


Fig.5. *Contours of static pressure over NACA 0012 airfoil with 20 serrations*

6. Resultant values and graphs

Graphs of pressure variation of NACA aerofoil with and without serrations

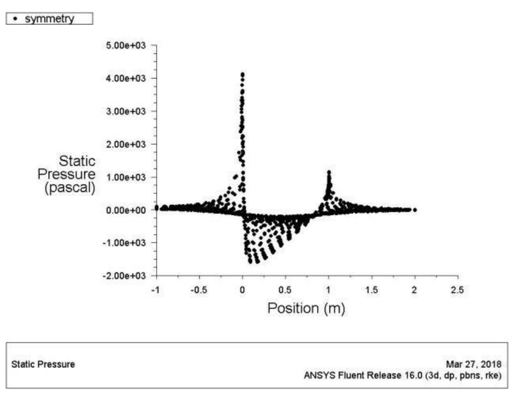


Fig.6. *Graph of pressure variation along NACA 0012 airfoil without serration*

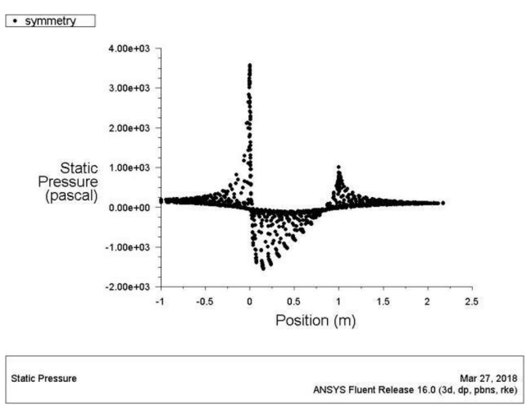


Fig.7. *Graph of pressure variation along NACA 0012 airfoil with 8 serrations*

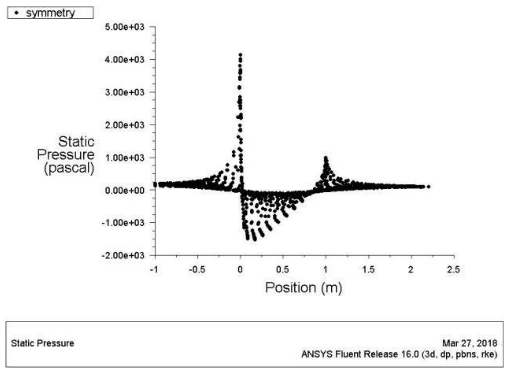


Fig.8. *Graph of pressure variation along NACA 0012 airfoil with 10 serrations*

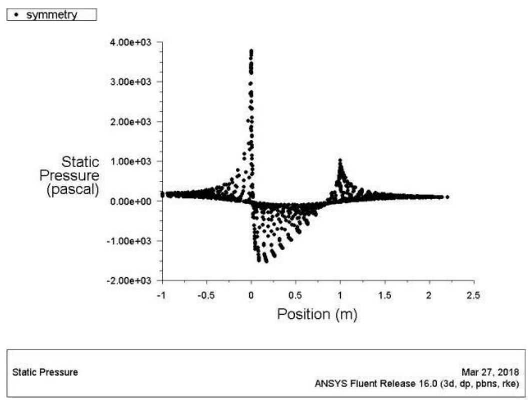


Fig.9. *Graph of pressure variation along NACA 0012 airfoil with 20 serrations*

7. Conclusion

Based on the CFD analysis of the flow over NACA 0012 airfoil we can conclude that the simulations conducted for with and without serration aerofoil prove more lift is generated for 10 serrations when compared with other cases.

Compliance with Ethical Standards

Conflicts of interest: Authors declared that they have no conflict of interest.

Human participants: The conducted research follows the ethical standards and the authors ensured that they have not conducted any studies with human participants or animals.

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