Design Analysis and Optimization Of Wing With Variable Camber Continuous Trailing Edge Flap

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***Abstract*: The lift and drag characteristics of the aircraft performance is achieved by high lifting devices. In this work the design, analysis of a swept wing with flap section is done. Due to variable flight condition, the wing attains a various drag at the span section. Therefore the wing optimization can increase the lift to drag ratio and improve the aerodynamic efficiency of the aircraft. The design of the flap contains three airfoil sectionswith equal chord length and the slotted flap type is used for the cambered section of the airfoil. The design of the wing is drawn by CATIA V5 and the analysis was done through ANSYS 14.5 to determine the lift distribution during takeoff and landing condition.**

Keywords: Aerodynamics, Variable Camber-Airfoil, Variable Camber Continuous Trailing Edge Flap(VCCTEF),Drag Optimization.

I.INTRODUCTION

The major problem in aerodynamic design is to produce high – lift with minimum drag aerodynamic characteristics. The higher C_{Lmax} in a transport aircraft gives better takeoff and landing performance. Improve the fuel efficiency is one of the problems that affect thedecrement of fuel level can cause the lift to drag ratio.Structural design of the aircraft because the light weight material provides a structural rigidity and gives sufficient load carrying capacity. The lift and drag coefficient affects the aerodynamic efficiency. The structural flexibility always influences the aero elastic behavior with aerodynamic forces and moment coefficient that can changes the aerodynamic of the aircraft. A fully new concept is used to improve the drag reduction withtheflap system. The concept is VARIABLE CAMBER TRAILING EDGE FLAP (VCCTEF) provides much more lift and minimizing the drag coefficient. The VCCTEF method is not affect by deficiency of fuel level and additionally fuel saving is possible with that concept of variable camber. The variable camber trailing edge flap (or leading edge slat) comprises multiple chord-wise segments (three or more) to form a cambered flap surface and multiple span-wise segments to form a continuous trailing edge (or leading edge) curve with no gaps. Aerodynamic simulations have shown that this type of flap can reduce aerodynamic drag substantially as compared to a conventional flap.

II.VARIABLE CAMBER FLAP CONCEPT

The slotted flap is used for the variable camber flap concept. Its aim is to reducing the wing drag at speeds below the design speed without increased complexity or weight when compared to a conventional plain flap. The flap chord is comprised of three chord wise segments of equal chord length as shown in Figure. The variable camber flap creates same downwash as a simple plain flap deflected by the same angle.

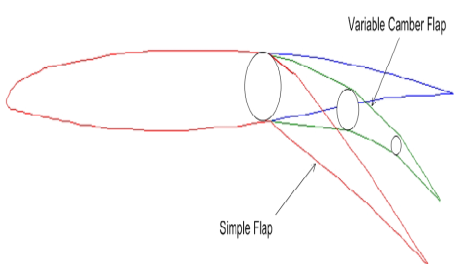

Fig: 2.1 Basic geometric design of the variable flap

Geometric characteristics are:

The upper surface of the airfoil is fixed for all the flaps and to the airfoil for all flap deflections; the flap rotation is generally very far below the airfoil chord. The deflections is very small,Having positive deflections .The flap deflection angle, δ and the wing angle of attack, α, are the design variables used to minimize the wing drag subject to the lift required. The variable camber flap does not allow perfect camber because of the increment camber and chord.The general geometry and the VCCTEF concept possess different performing level. The VCCTEF flap concept provides the conversion of static to parametric model leads to discrepancy errors and the efficiency can be improved due to the continuous variable camber flap techniques when compared to the normal conventional model of the aircraft performance. The lift can increased in the parametric model of the aircraft. In addition to this wing shaping, gap removal are also performed very well.

The variable camber concept is used for the high lifting devices at the trailing and leading edge sections. This concept mostly reduces the drag coefficient. The high lifting device is now changed into variable camber wing. Generally high lifting devices increases lift but in this concept, the variable camber provides no discontinuities and changing the curvature of the airfoil section.In addition to this, actuation system also involved inthis concept.

III.IMPROVEMENT OF LIFT TO DRAG RATIO

Elastically shaped wing can be achieved by flexible aerodynamic surfaces and local angle of attack is to increase the efficiency of the wing section that can minimize the reduction of drag during takeoff, landing and cruise condition. The main aim of the (VCCTEF) is to increase the drag with respect to low drag coefficient. Using variable camber flap concept for the lift improvement and the flap section is designed with the three flap sections connected through the actuation system gives variable camber. It will controlthe wing shape and twist to improve the lift – drag ratio. The flexibility in the cambered airfoil provides the wing to reduce the drag through the variable camber section. The bottom and top surface of the wing is tighter. The curvature that is made by the variable camber section that creates the reduced drag over the wing section. The top surface of the airfoil section becomes smoother when the wing attains a cambered curve. The bottom surface of the wing is always tighter. The improvement of the lift to drag ratio is due to the flap angle that can be achieved by the variable camber flap section.

IV. DESIGN CONCEPT

The set of NACA airfoil is connected through Slotted flap creates variable camber. Each section rotates up to fifteendegree. In early stage of researches was done by changing the camber section of leading edge and trailing edge to attain a lift without having a gap between the portions of the wing.In this concept, the wing section can able to attain a smooth surface with cambered profile. The wing section is divided into three section can give free rotation and airfoil shape changes.

Each rib section is connected by three airfoil with equal chord so it can provide free rotation of the rib section. The NACA airfoil is used with three sections at the trailing edge region. The sections are cut into circular arc at the flow over the wing sectionexcept at the leading and trailing edge end portion. The lift generated from the cambered wing is very much higher when compared with the rigid section because the cambered wing possess some amount of vibration possible across the wing section that will maintain the flow over the wing section become perfectly smooth.

V.DESIGN AND ANALYSIS

Reference aircraft model:

The model selected for the study is a notional single-aisle, mid-size, 200-passenger aircraft having a similar outer mold line as Boeing 757. The geometry of the model aircraft is obtained by scaling up the geometry of aircraft. The main reason for selecting this model vehicle is that the extensive wind tunnel aerodynamic database already exists that would be used in the study for validating results of the optimization study. The model configuration represents provides short-to-medium range passenger carrying capacities.

The plan of this study is to examine a multi-disciplinary design, analysis and optimization to get the potential benefits of the elastically shaped futureair vehicle concept over a conventional vehicle design.

a.3D model of the aircraft:

The flap chord is comprised of three chord wise segments of equal chord length.A cambered flap is more effective in producing lift than a straight uncambered flap.These devices are primarily used to improve the maximum lift coefficients of wings with changing the characteristics for the cruising and high-speed flight conditions.

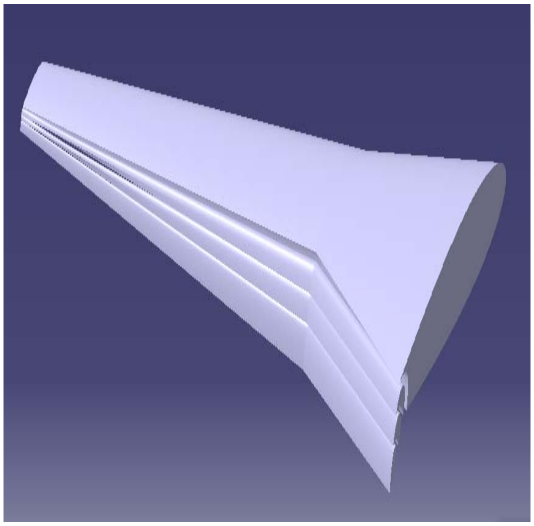

Fig: 5.1 Variable cambered wing model

b. Domain region of the model:

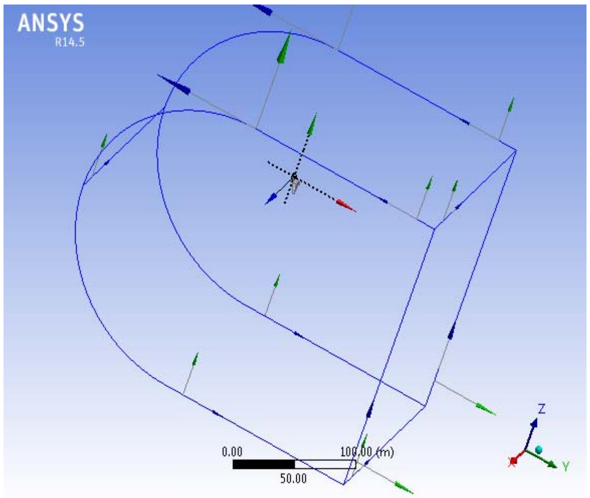

Fig:5.2 Domain regions around the wing

c.Meshing:

The airfoil profile is engendered in the Design Modeler and boundary conditions, meshes are created in the pre-processor ICEM-CFD.Structured or unstructured meshes consisting of quadrilateral, triangular or tetrahedral elements.

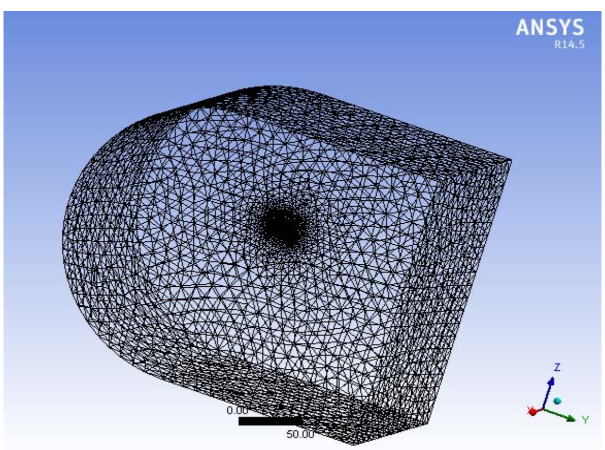

Fig: 5.3 Domain regionwith mesh

Commercial grid generator ANSYS ICEM CFD is used to mesh our domain. Shown in Fig:5.2 presents the single element **NACA 0021** domain as it extends 20 chord lengths downstream and 13 chord lengths to the sides and upstream.

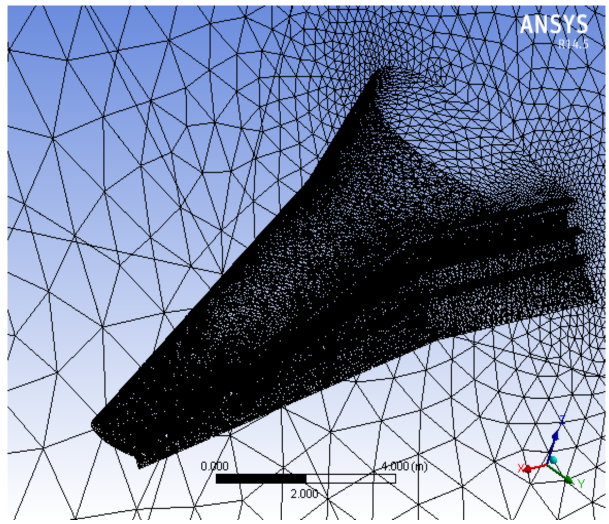

Fig: 5.4 Meshed region of the wing

The resolution and density of the mesh is greater in regions where superior computational accuracy is needed, such as the near wall region of the airfoil.

VI.RESULT AND DISCUSSION

The variable camber continuous trailing edge flap produces the drag reduction goal. This concept having the flexibility and effectiveness of wing shaping control.in conventional flap the actuation is independent therefore it results discontinuity in the trailing edge flap. But, here there is no discontinuities occurs in the variable camber continuous trailing edge flap concept (VCCTE)

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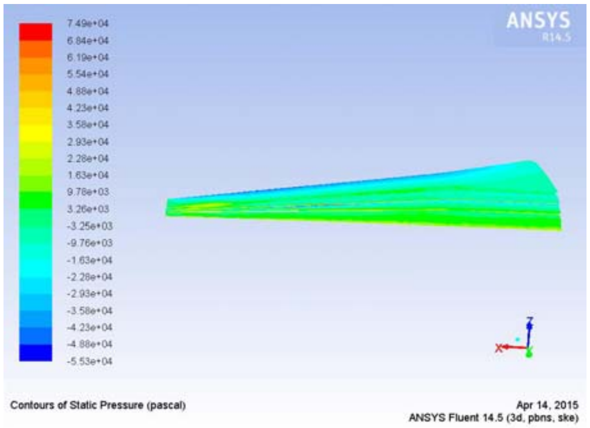

Fig: 6.1Contours of static pressure

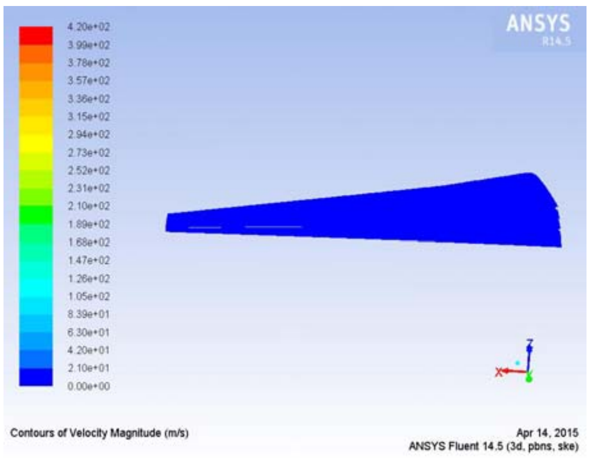

Fig: 6.2 Contours of velocity vector

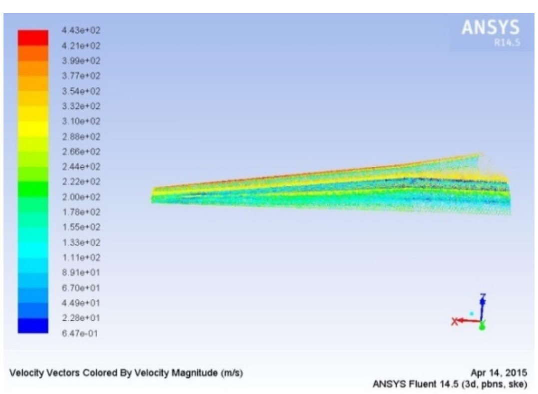

Fig: 6.3 velocity vector for velocity magnitude

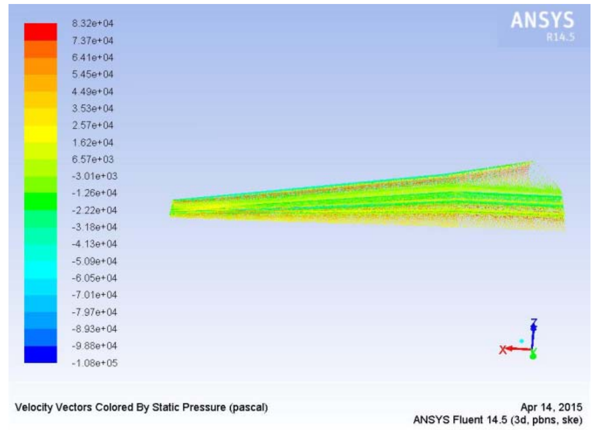

Fig: 6.4 velocity vector by static pressure

VII.CONCLUSION AND FUTURE WORK

Continuous trailing edge would reduce the vortices formation while conventional flap discontinuity occurs at the trailing edge region. Therefore the continuous trailing edges with variable camber trailing edge is used to attain a significant reduction of drag and in addition to this elimination of vorticities at the trailing edge are also taken into account for the good results of lift generation.

The variable camber continuous trailing edge flap concept is implemented in the ADJOINT SOLVER to estimate the potential drag reduction benefit in future work.

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