Analysis on Reducing the Induced Drag Using the Winglet at the Wingtip

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Abstract

The winglet reduces the induced drag at the wing tips and increases the lift to drag ratio. Wingtip devices are usually intended to improve the efficiency of fixed-wing aircraft. The winglet also reduces the fuel usage and increases the single engine performance. This paper deals with Analysis of reducing the induced drag using winglet at the wingtip. We have considered the Boeing 767 wing and attached the winglet to analyze the performance. Winglets are mounted on the wing tips as the vertical extensions. The comparisons were done to see the performance of winglet at different angles of attack. Wing and winglet are designed in Catia V5 then analyzed in Ansys CFX workbench and Fluent to reduce the vortices at the wingtips.

1. Introduction

One of the primary obstacles limiting the performance of aircraft is the drag that the aircraft produces. This drag is created due to the vortices shed by an aircraft's wings, which causes the local relative wind downward and generated a component of the local lift force in the direction of the free stream called induced drag. The strength of this induced drag is proportional to the spacing and radii of these vortices. By designing wings which force the vortices farther apart and at the same time create vortices with large core radii, one may significantly reduce the amount of the drag the aircraft induces.[3]

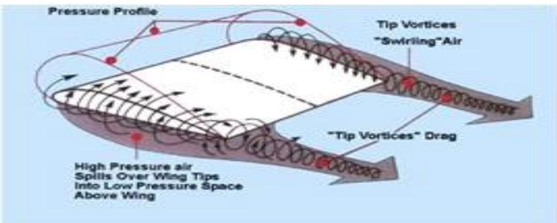

Fig1: Vortices occurring at the wingtips

Wingtip devices are used to improve the efficiency of fixed-wing aircraft [1]. Winglets can also improve aircraft handling characteristics. The wingtip devices increase the lift generated at the wingtip, and reduce the lift-induced drag caused by wingtip vortices, improving lift-to-drag ratio. Winglets improve efficiency by diffusing the shed wingtip vortex, which in turn reduces the drag due to lift and improves the wing's lift over drag ratio [2]. Winglets increase the effective aspect ratio of a wing without adding greatly to the structural stress and hence necessary weight of its structure.

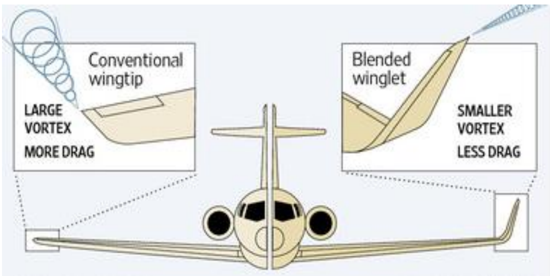

Fig2: Vortices forming for conventional wingtip and for blended wingtip

In this paper we have considered the Boeing 767 wing, designed it in CATIA. The airfoil NACA 2213 coordinates are initially imported into catia from the design foil software. Then the coordinates are joined using spline, extruded and attached with a blended winglet structure. This wing without winglet is kept at 4º, 8º, 12º angles of attack and analyzed in Ansys software using the CFX workbench. The same procedure is followed for the other wing with circular winglet and wing without winglet. By analysis the performance of the wing with winglets can be estimated.

2. Design

A. Design of airfoil

The **NACA** airfoils are airfoil shapes for aircraft wings developed by the National Advisory Committee for Aeronautics (NACA). The shape of the NACA airfoils is described using a series of digits following the word "NACA". The parameters in the numerical code can be entered into equations to precisely generate the cross-section of the airfoil and calculate its properties.

The NACA four-digit wing sections define the profile by first digit describing maximum camber as percentage of the chord, second digit describing the distance of maximum camber from the airfoil leading edge in tens of percents of the chord and last two digits describing maximum thickness of the airfoil as percent of the chord.

The design foil software helps to know shape of the airfoil. It is designed such that we can create a number of airfoils in this software there are many airfoil data installed in it. The design foil software also enables us to send the airfoil into design software like CATIA or AUTO CAD etc. This software is being used by many companies to generate the shape of the airfoil easily and import that to the design software. The design foil software helps in obtaining the coordinates of the airfoil we required for different chord lengths so that they can be imported into the catia for the generation of airfoil shape.

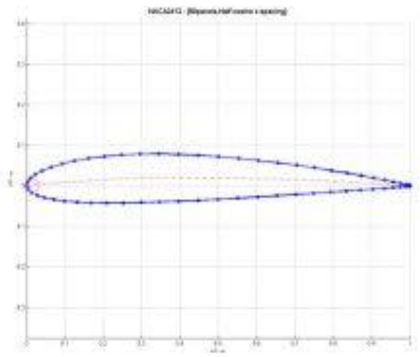

Fig3: Airfoil coordinates

B. Design of Wing

Importing these coordinates into Catia and designing the wing using the tools as shown in figure. The blended winglet and the circular winglet is attached to the wing as shown in fig and fig.

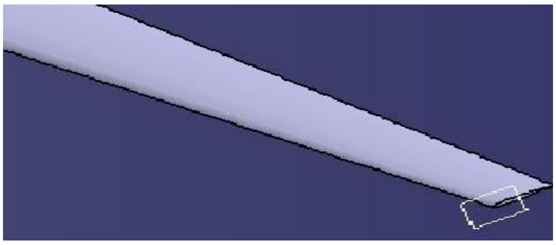

Fig4: Wing without any winglet

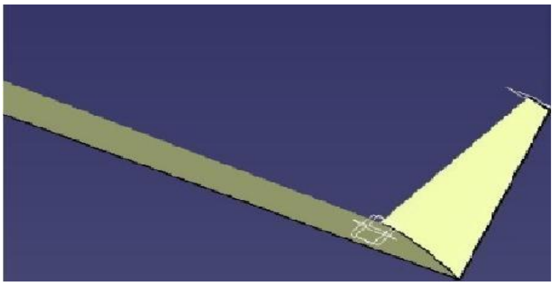

Fig5: Wing with blended winglet

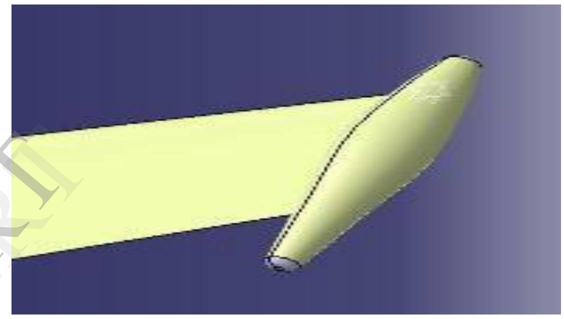

Fig6: Wing with circular winglet

3. Analysis

The analysis is done for all the three wings using the Ansys-Fluent workbench by giving the initial and boundary conditions as pressure inlet and velocity outlet to find the coefficient drag(C_d) for each wing. The flow on the wing without winglet, wing with blended winglet and wing with circular winglet is analysed and the C_d is estimated.

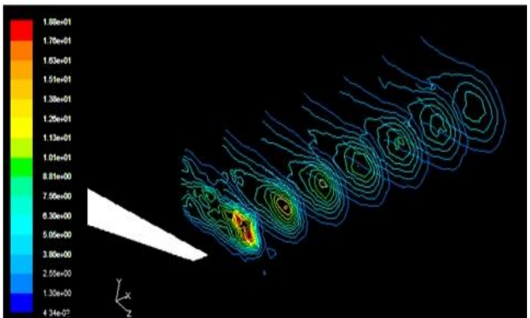

Fig7: Vortices formed for wing without winglet

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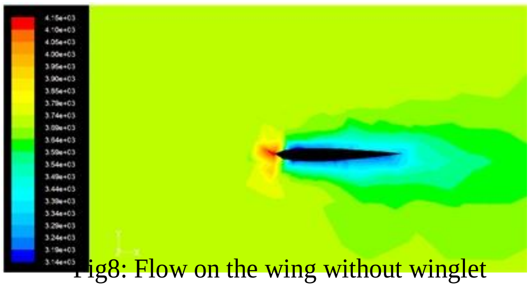

Fig8: Flow on the wing without winglet

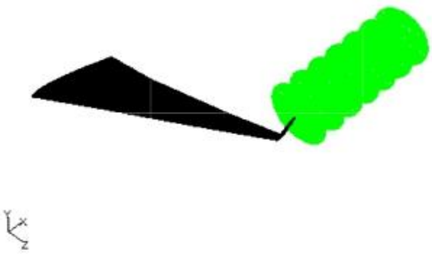

Fig9: Control zones for showing vortices for wing with blended winglet

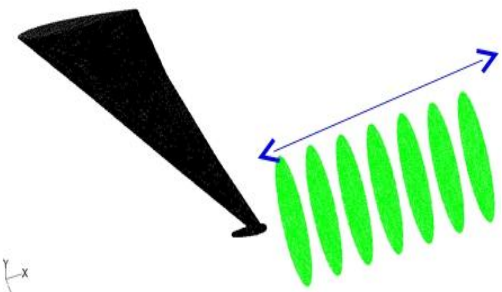

Fig10: Control zones showing vortices for wing with circular winglet

4. Results and Discussions

The analysis on the three wings with winglets at 4°, 8° and 12° angles of attack obtained the performance in terms of C_d. Variations of the C_d for each type of winglet are tabulated in the table

Angle of Attack	C_d with no winglet	C_d with blended winglet	C_d with circular winglet
4°	0.014612	0.014625	0.014727
8°	0.030215	0.029759	0.030380
12°	0.056377	0.055641	0.057239

Table1: Analysis results for C_d

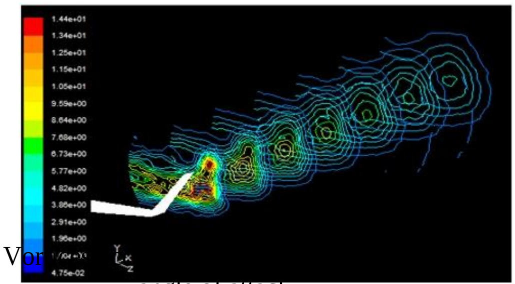

Fig11: Vor … angle of attack

5. Conclusion

The results obtained after the analysis shows that the blended winglet gives the better performance compared to the wing without winglet and wing with circular winglet. The C_d obtained for the blended winglet is less in all angles of attack. The best C_d is obtained when the wing is kept at 12° angle of attack.

6. References

[1] Mohammad Ilias Inam, Mohammad Mashud, Abdullah-Al-Nahian and S. M. S. Selim, "Induced Drag Reduction for Modern Aircrafts without Increasing the Span of the Wing by Using Winglets", IJENS, Bangladesh.

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[3] Altab Hossain, Ataur Rahman, A.K.M.P. Iqbal, M. Ariffin and M. Mazain, "Drag Analysis of an Aircraft Wing Model with and without Bird Feather like Winglet", International Journal of Aerospace and Mechanical Engineering, 2012.