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ANALYSIS OF DRAG OVER A WING MODEL WITH & WITHOUT RAKED WINGTIP

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ABSTRACT

The main motive of the proposed paper is the numerical investigation of Wing model with and without winglet. Here the investigation shows the various performance and parameters for the wings when designed with a winglet and without a winglet and thus comparing the parameters for both the designs. Here discussions were focused on the aerodynamics characteristics like drag coefficient C_D lift coefficient C_L, and lift-to-drag ratio L/D. NACA 65_3-218 Rectangular airfoil design used in this investigation. The Geometry of the models is carried and designed in the CATIA V5 Software. The main objectives of this work is to reduce the induced drag formed on wing during the fight operation, thus improving the efficiency of the aircraft. The analysis part is done by using the ANSYS Software, flow parameters (like lift and drag) are measured for different design configurations.

KEYWORDS: *Aerodynamics, Airfoil, Drag coefficient, Lift coefficient, Winglets.*

1. INTRODUCTION

This research is used to explore the shapes of winglet design. While during research over the winglets has been overcome by conventional winglets, with some research carried over multiple winglets [3], spiroid wingtip [4]-[5] and blended winglet [6]-[7], and Raked winglets. In this project, have taken the NACA $65_3$218 airfoil[5] to design rectangular wing & Raked wingtip with 660 mm span and 121 mm chord. The raked wingtip has a high degree of sweep than the rest of the wing. So raked wing tip were designed with 30º & 45º angle has been used. It has designed in CATIA and the aerodynamic characteristics were compared.

2. WING DESIGN

The first step of the project was creating geometry of the model using CATIA V5R13. Then grid was generated. The second step was simulating the computation by FLUENT solver. Final step is post-processing stage where the aerodynamics characteristics of the winglets were found. The rectangle and raked wing model have been designed in Catia V5. Raked wing tip with 30º & 45º angle have also been built. In order to do that, an airfoil section was picked as well as a data file was created with the airfoil points. To work in Catia V5, it was necessary to create an excel table with all its lower and upper surfaces airfoil points. A NACA $65_3$218 was chosen to develop the wings. Later on, used that airfoil at the wing root airfoil and at the wing tip airfoil.

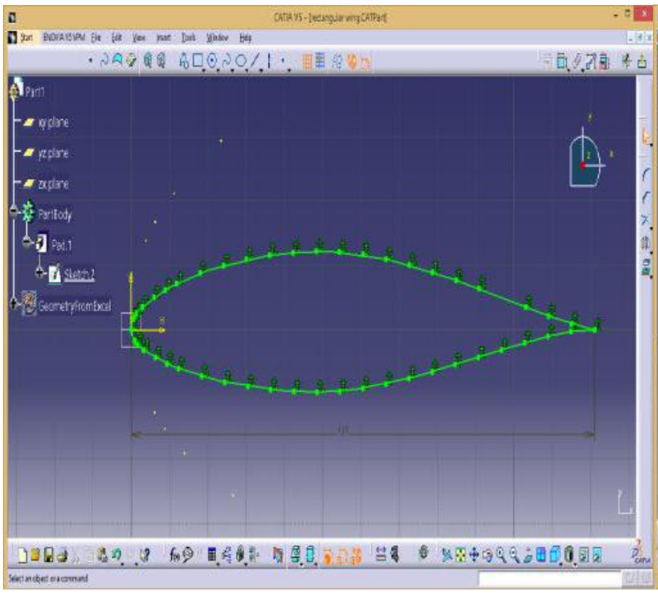


Fig. 1: NACA 653218 airfoil in CATIA V5

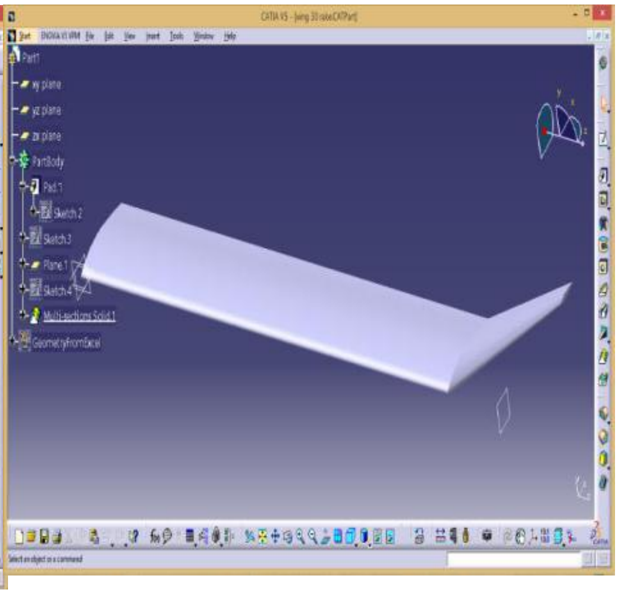


Fig. 3: Raked winglet with 30°

After designed this airfoil in CatiaV5, the rest of the airfoil model was drawn. To do that, have to shift and scale the initial airfoil to build the wing model. When the airfoils were located at the right place, regarding the sketches, extrusion of sections is done in Catia V5. The wing model before used extrusion of sections option is in figure.

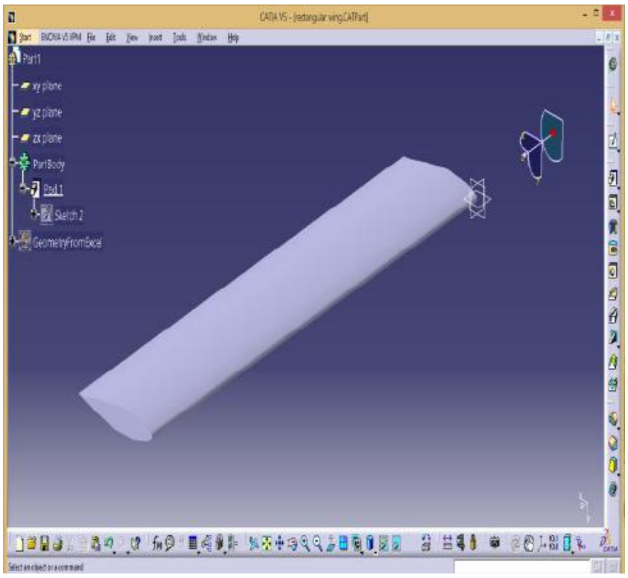


Fig. 2: Complete Rectangular wing

Until now, all have done is drawing the wing model without winglet. The process of sketching Raked wingtip model with two different angles are similar. In the following figures 3 & 4, we can see the wings with Raked wingtip.

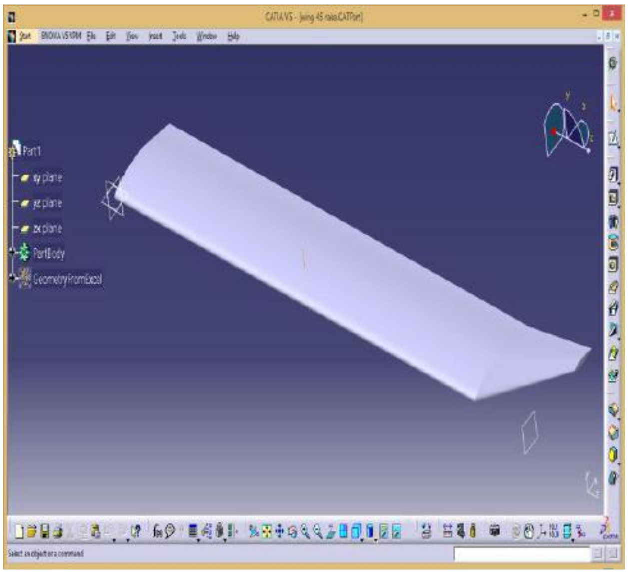


Fig. 4: Raked winglet with 45°

The numerical simulation was made by the solver[6], after completing the mesh generation. Then solution control parameters and material properties were defined. After all the parameters were identified, the model was initialized. The initializing and iteration processes were stopped after the completion of the computation work. After that results obtained were examined and analyzed.

3. RESULT AND DISCUSSION

In this section, FLUENT results will be shown and discussed. To do that, have to study the different wings from various angles of attack between 0 and 8 degrees. After that Wingtip vortex development and its performance have been verified in the first part. In additional, wingtip vortices are reduced here. Wingtip vortex is rotating about its axis and started to turn nearby its wingtip and the axis in which wingtip vortex moved down. The wingtip vortices rotates anticlockwise in the models. Vorticity magnitude is related to lift and the wingtip vortex intensity will be verified when the lift increases. At the end Finalized table will be showed in which the drag coefficient improvement can be compared. The set of results will be given in several tables, diagrams or figures.

3.1. *Path lines:-*

From the figure 5 and 6 represent the path lines view of flow over the winglets at maximum velocity of 150 m/s and maximum angle of attack of 8 degree. Those path lines were focused at the tip of the wing where trailing vortices occurs. The trailing vortices formed greatly at high angle of attack, when an airplane takes off.

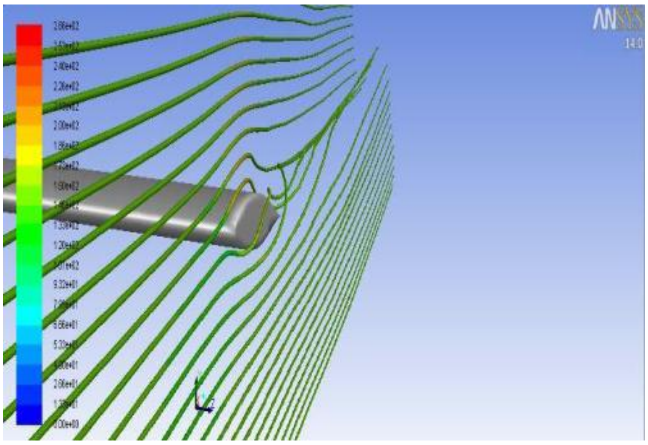


Fig.5: Pathlines for Rectangular wing at α =8°

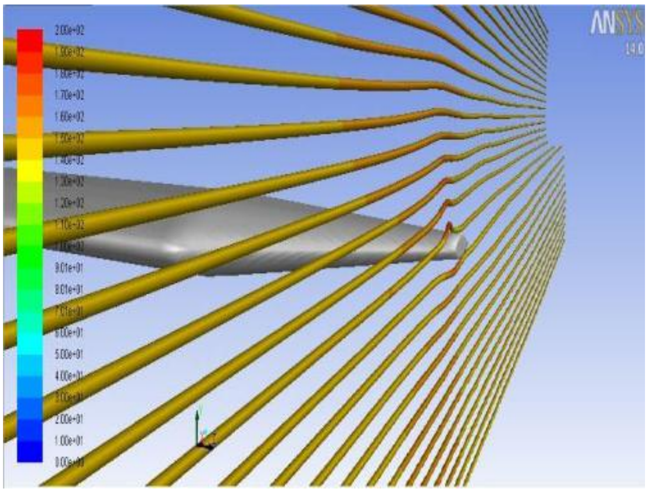


Fig. 6: Pathlines for Raked winglet of 45 Degree at α = 8°

From the result, the rectangular wing without winglet produces greater trailing vortices than the rectangular wing with winglet. The Raked winglet with 45 degree cant angle greatly reduces the trailing vortices among all winglets.

3.2. *Pressure Coefficient Contours:-*

From the figure 7 to 10 shows pressure coefficient contour (top and bottom surface) of winglet at maximum velocity of 150 m/s and at 0 and 8 degree angle of attack. When the angle of attack, α increases, the upper surface will produce a low pressure coefficient. The high intensity blue area placed on the upper surface which suggests high lift is generated.

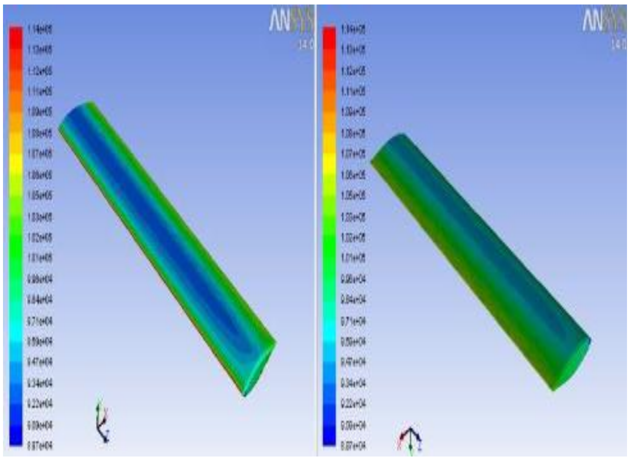


Fig. 7: CP contours for Rectangular wing at α = 0°

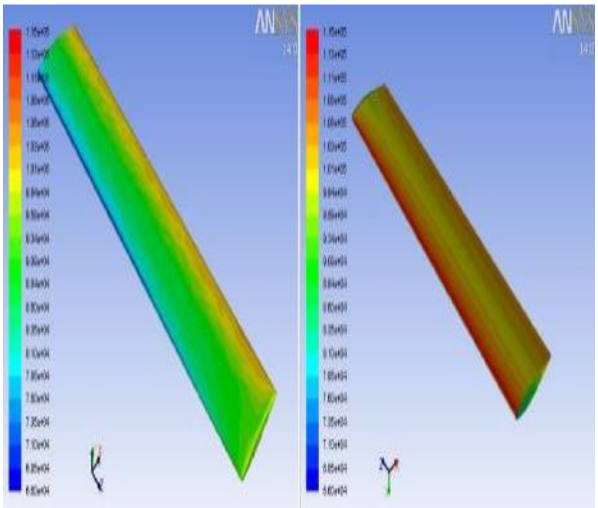


Fig. 8: CP contours for Rectangular wing at α = 8°

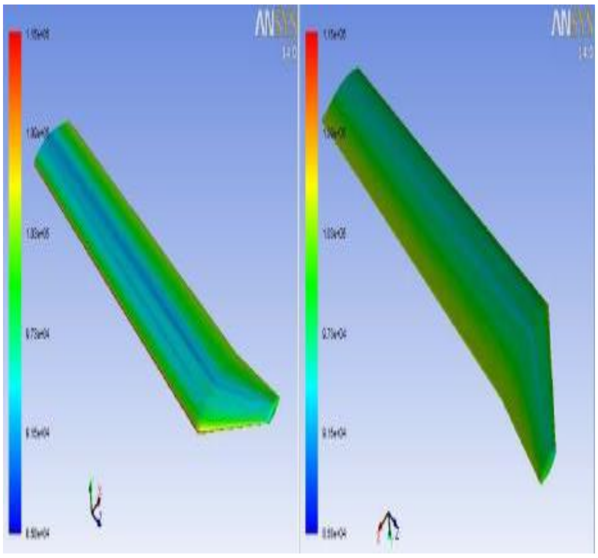


Fig. 9: CP contours for Raked winglet of 45 Degree at α = 0°

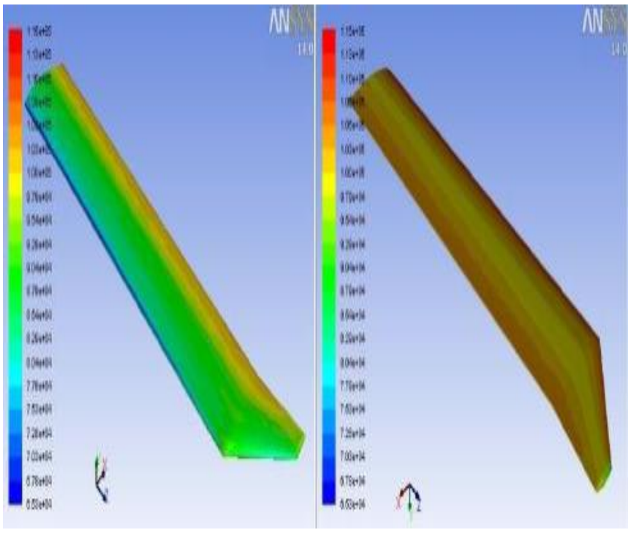


Fig. 10: CP contours for Raked winglet of 45 Degree at α = 8°

3.3. *Drag coefficient improvement:-*

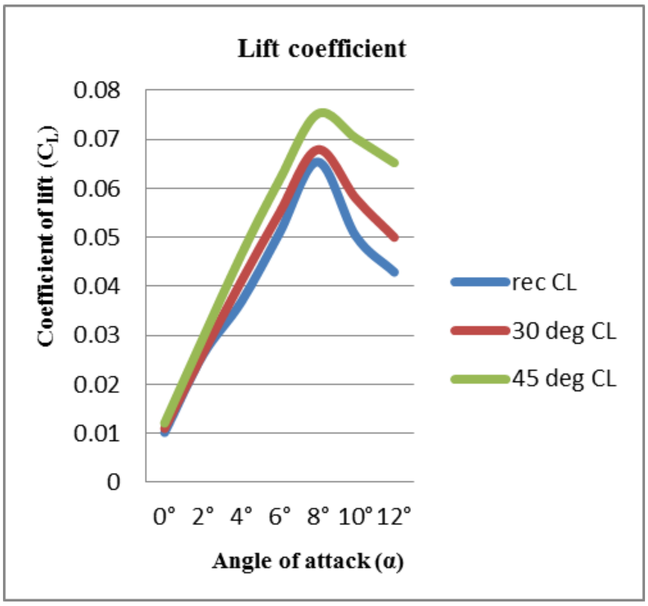
The main goal of this project is to check how winglets are able to reduce drag coefficient. The following tables and graphs shows lift coefficient, drag coefficient and ratio of lift and drag coefficient wing models is increased when winglets are linked to wingtips with 30° and 45° angles of attack, between 0° and 12°.

3.3.1. *Coefficient of Lift:-*

The coefficient of lift vs angle of attack for the aircraft wing model with and without winglet obtained in the current analysis were shown. From the figure it is observed that the lift increases with increase in angle of attack to a maximum value and thereby decreases with further increase in angle of attack.

Lift	Rec	30 deg	45 deg
Angle of Attack	C_L	C_L	C_L
0°	0.0102	0.011	0.0121
2°	0.026	0.0263	0.0294
4°	0.0368	0.041	0.0464
6°	0.0509	0.055	0.0617
8°	0.0654	0.0679	0.0752
10°	0.0502	0.0579	0.0702
12°	0.0429	0.05	0.0652

Table 1: Lift coefficient



Graph 1: Lift coefficient

3.3.2. *Coefficient of Drag:-*

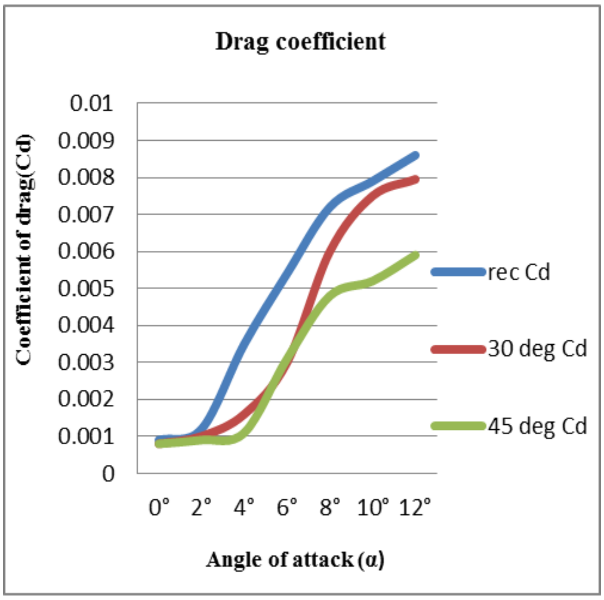
The drag coefficients of the aircraft wing model with and without raked winglets were shown. The drag increases slowly with increase in angle of attack to a certain value and then it increases rapidly with further increase in angle of attack.

Drag	Rec	30 deg	45 deg
Angle of Attack	C_d	C_d	C_d
0°	0.0009	0.0008	0.0008
2°	0.0012	0.001	0.0009
4°	0.0035	0.0016	0.0011
6°	0.0054	0.0042	0.0031
8°	0.0072	0.006	0.0048
10°	0.0079	0.0075	0.0052
12°	0.0086	0.00795	0.0059

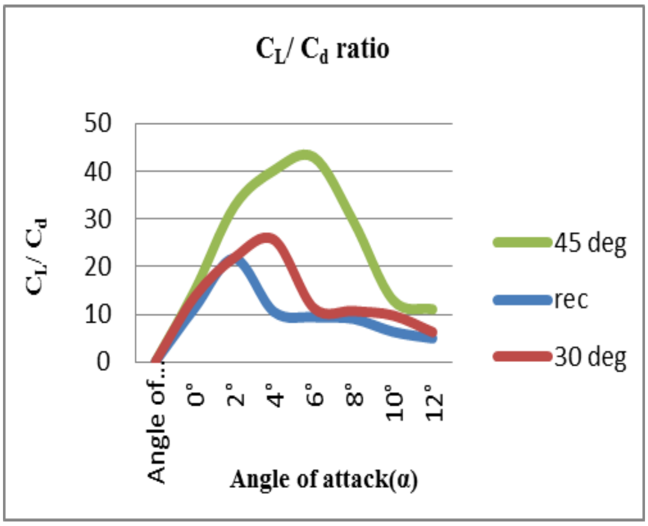
Table 2: Drag coefficient

Ratio	rec	30 deg	45 deg
Angle of Attack	C_L/C_d	C_L/C_d	C_L/C_d
0°	11.3333	13.75	15.125
2°	21.6667	21.9167	32.6667
4°	10.5143	25.625	40.1818
6°	9.4259	11.3095	42.9032
8°	9.0833	10.7	29.5
10°	6.3544	9.772	12.9655
12°	4.9883	6.289	11.05

Table 3: Ratio of lift and drag coefficient



Graph 2: Drag coefficient



Graph 3: Ratio of lift and drag coefficient

3.3.3. *Ratio of lift and drag coefficient:-*

The ratio of lift and drag coefficient is observed from the result. That the lift to drag ratio for all the configurations considered increases with an angle of attack upto its maximum value.

From the result it clearly shows the wingtips vortices intensity is related to lift. If the wing works at high angles of attack then the lift is increased. Therefore, we can expect better result at high angle of attack, since the wingtip vortex reduction will be higher, raked winglet works better with high angles of attack. The best winglet is raked winglet because it can able to reduce the Cd conveniently, and the best drag coefficient reduction occurs at working.

4. CONCLUSION

Experiments have been performed to examine the efficiency of Raked winglets to improve the performance of a wing in subsonic flow and reduce the fuel consumption of an aircraft[3]. CFD is used to predict the performance of the winglets[2], huge amount of money and time can be saved before testing the winglet in the wind tunnel. Modification can also be done at this stage, thus shortening the time before it coming out with the optimum design.

Following are the conclusions drawn from this investigation.

1. From the graph, it is clearly shown that using Raked winglet will increase the lift and reduce drag force.
2. From the design, winglet can able to reduce induced drag force and it converts wing tip vortices to extra thrust which will save cost by reducing the usage of fuel, noise level and increase the efficiency of the aircraft engine.
3. The result proves that 15-20 % increase in lift coefficient and 20-25 % reduction in drag coefficient by using winglet at 8 degree for angle of attack.

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