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CFD Analysis of Split Scimitar Winglets in Lighter Aircrafts

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Abstract

A winglet is a device attached at the wingtip, used to improve aircraft efficiency by Lowering the induced drag at the tips of each wing .The objectives of the analysis were to compare the aerodynamic characteristics of these winglets and to investigate the performance of the three winglets shape simulated at selected angle of attack and for various velocities. The computational simulation was carried out by CFD solver using finite volume approach. A comparison of aerodynamic characteristics of lift coefficient, drag coefficient, and lift to drag ratio was made and it was found that the addition of the scimitar winglet gave a larger lift curve slope and higher lift to drag ratio comparison to the baseline wing alone in this project the analysis computational fluid dynamic of split scimitar winglets by using the software of ANSYS.

1. INTRODUCTION

A winglet device is used to improve the efficiency of an aircraft by reducing the lift induced drag which is caused by wingtip vortices [1]. The device is a vertical and may be also angled extension at the tips of each aircraft wing. Winglet increases the efficiency of wingtip vortex, which will decrease the aerodynamic drag due to lift and highly improves the aircraft wing's lift over drag ratio. Winglets improve the effective aspect ratio of a wing without adding greatly to the structural stress and therefore necessary weight of its structure doesn't affect. Research on winglet technology for commercial aviation was initiated by Richard Whitcomb in the mid 1970's. Small and nearly vertical fin shaped structures were installed on a KC-135A and flights were tested in 1979 and 1980. Winglets can provide improvements in efficiency of more than 7%. For

METHODOLOGY

In this project the computational steps consist of three stages as shown in fig. 1. The project starts from preprocessing stage

Which involves the basic aerodynamics characteristics of the winglets were found

Three stages of project

- Pre processing
- Numerical computation
- Post processing

Geometry setup was made by using surface design and wireframe to draw

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the 3-dimensional model of winglet.

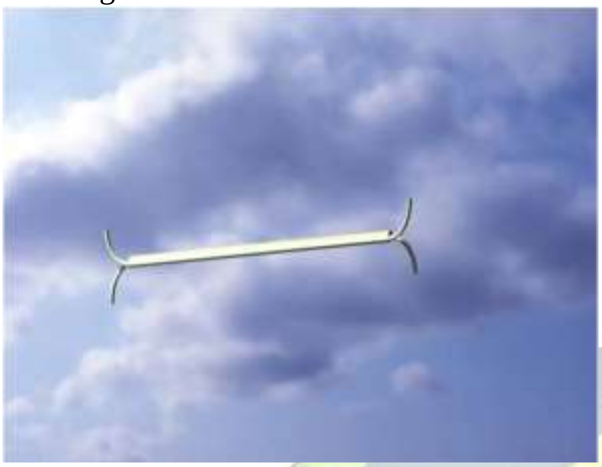

Fig. 1: Split Blended Winglet

The grid generation part was done using ICEMCFD. The 3- dimensional unstructured tetrahedral mesh was utilized for computing the flow around the model. Unstructured mesh is appropriate whether complexity of the model. The advantages of the unstructured mesh are shorter time consumption in grid generation for some complicated geometries and it's potential to adapt the grid to improve the accuracy of the computation. After completing the meshing process, the unstructured mesh was examined. The purpose of examining the meshes was to check on the quality of mesh by observing the level of skewers and unexpected changes in the cell sizes.

Then, the grid generated were developed using size function scheme in ICEMCFD. This will enable finer mesh at the winglet wall and then incrementally increase up to the boundary wall which is bullet shaped. The sizing function scheme will help to reduce the computational time. After the completion of the mesh generation the numerical simulation by the solver was made. The solver formulation turbulence model k-epsilon, boundary condition solution control parameters and material properties were define. The model was initialized after all the parameters were specified.

According to the necessary data. The initializing and iteration processes stopped after the completion of the computations. The results thus obtained were examined and analyzed.

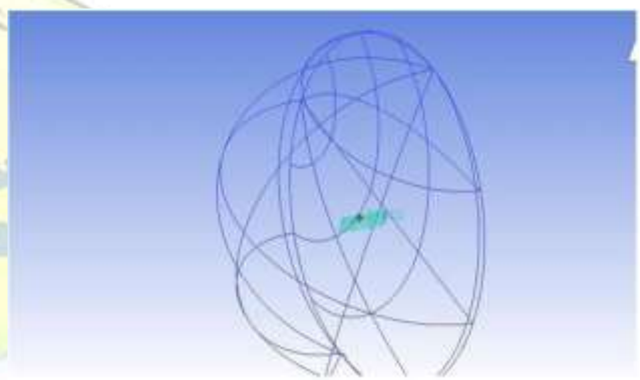

Fig. 2: Bullet shaped boundary wall

Fig. 3: split

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scimitar wing model

2. RESULTS AND DISCUSSION

The result from the 3-dimensional rectangular wing with winglet model was compared with wing without winglet model. The discussions were mainly focused on the aerodynamics characteristics which include drag coefficient, lift coefficient and lift to drag ratio. In addition to that the pressure coefficient contours and stream patterns will also be observed and studied. The simulation was carried out at various velocities 20,30,40,45 m/s and at various angle of attack 0,10,12,15 degrees respectively.

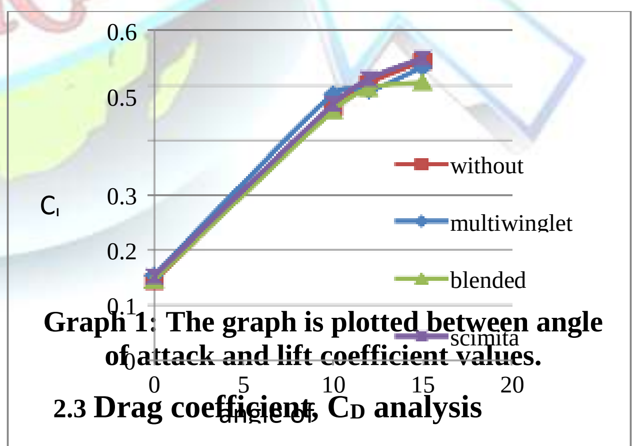
2.1 Lift coefficient, C_L analysis

Table 1 shows lift coefficient changes with angle of attack for all winglet and rectangular wing models at various velocities. Here is the result of C_L at velocity 45m/s is highlighted.

Table 1: C_L at velocity 45m/s

Winglet configuration	Lift coefficient			
	0	10	12	15
Without winglet	0.175	0.365	0.543	0.543
Multi winglets	0.185	0.497	0.34	0.532
Blended winglets	0.1543	0.490	0.423	0.506
Split-blended winglets	0.162	0.498	0.586	0.521

The following graph shows the variation in lift coefficient values among different winglet configurations.



Graph 1: The graph is plotted between angle of attack and lift coefficient values.

2.2 Drag coefficient, C_D analysis

Table 2 shows the drag coefficient changes with angle of attack for all winglet and rectangular wing models at various velocities. Here the results at velocity 45m/s are highlight

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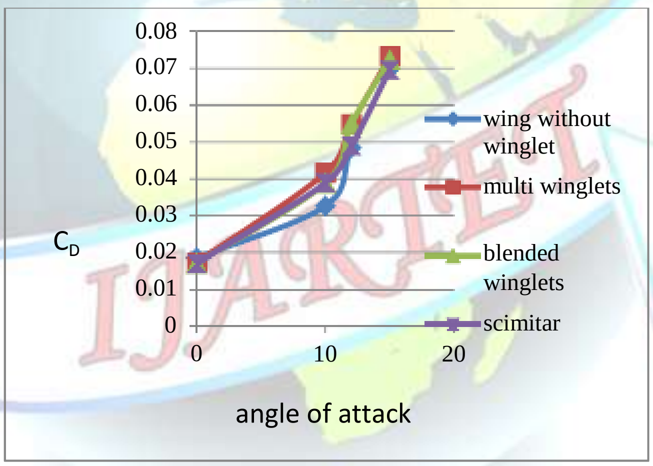
Winglet configuration	Drag coefficient			
	0	10	12	15
Without Winglet	0.021	0.035	0.03	0.04
Multi winglets	0.019	0.044	0.04	0.05
Blended	0.019	0.039	0.056	0.05
Scimitar Winglets	0.018	0.039	0.042	0.056

Table 2: C_D at velocity 45m/s



Graph 2: The graph is plotted between angle of attack and drag coefficient values.

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The following figures shows the streamline pattern of flow over baseline wing, wing with blended winglets and wing with split blended winglet at 45 m/s velocity and maximum of 15 angle of attack

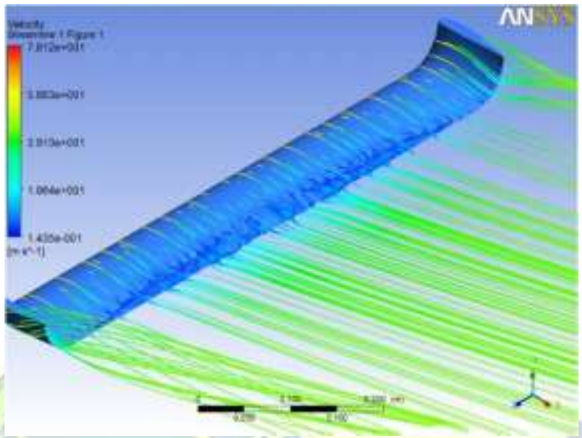

Fig. 4. Streamline pattern over wing without winglet configuration

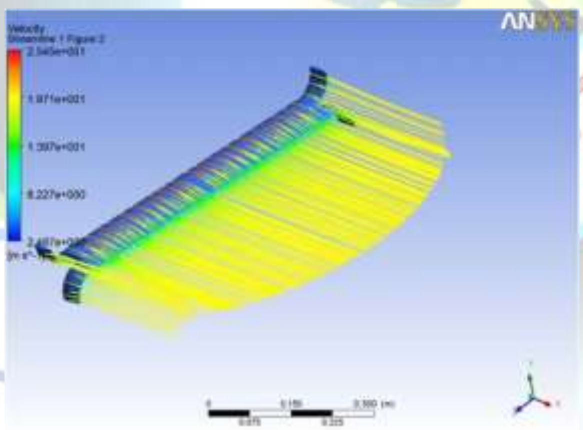

Fig. 5. Streamline pattern over wing with split blended winglet

4 .CONCLUSION

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This project proposes alternatives in the design of winglet from the conventional designs. An improved winglet design will significantly yield a better performance of an aircraft and reduce the fuel consumption. By using CFD to predict the performance of the winglets, huge amount of time and money can be saved before testing the winglets in the wind tunnel. Modification can also be done at this stage, thus shortening the time cycle before actually coming out with the optimum design.

Despite the benefits of winglets there are some drawbacks that need to be addressed. For example, the bending moment at the wing root is higher, and may require additional structural reinforcement of the wing. Winglets although can produce a drag wing, they add to the cost and complexity of construction. They also modify the handling and stability characteristics. The viscous drag of the winglet can be too big, nullifying the reduction of the induced drag. Winglets have to be carefully designed so that these and other problems can be overcome.

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