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Analysis of induced drag and vortex at the wing tip of a Blended Wing Body aircraft

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Abstract**—*The authors aimed with this work to study the "vortex" on the wing tip of a "Blended Wing Body" aircraft using computational tools available that use the methods of"finite element" and "Computational Fluid Dynamics". The purpose of it is to reduce the vortex intensity, improving stability, reducing the "induced drag" and promoting less turbulence in the aircraft. This new aircraft configuration is a little different from the ones we have today. Blend Wing Body aircrafts fuselage and wings are one body, changing a loot o fight characteristics.***

Keywords—Blended Wing Body, Computational Fluid Dynamics, Finite Element Method, Induced Drag, Vortex.

I. INTRODUCTION

The Blended Wing Body is a very new concept of aircraft airfoil. Great companies like Boeing and NASA have already made some studies in this field. The creation of new models are beingstudied more in order to create better airfoil models. The structural and fabrication study has started too, as like how to use the aircraft for commercial benefits. The Blended Wing Body aircrafts have many advantages compared with the conventional ones, such as more lift, less drag, and it can save more fuel during flights.This project consists in compare two models of BWB, aiming to reduce the vortex and the induced drag. One model has wing tip devices in the wing, called winglets, and the other one is a model without winglets.

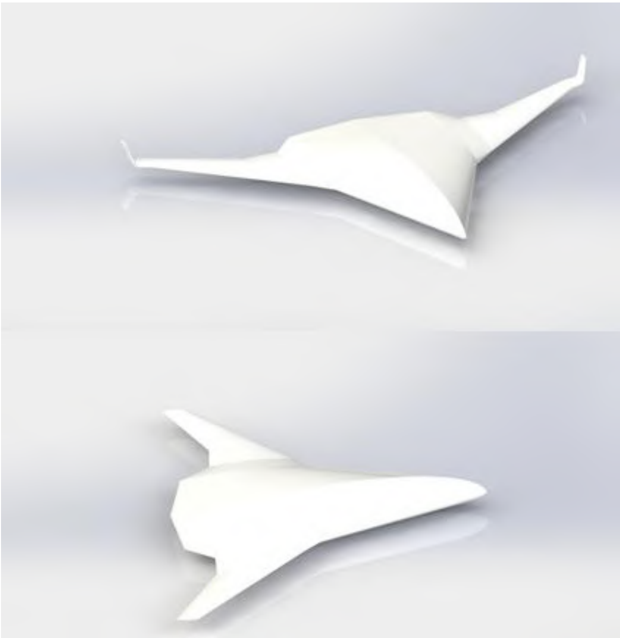

Fig.1: Blended Wing Body Models

II. METODOLOGY

To compare the two configurations was used a CAD software to analyze the models, and two different CAE models to simulate the flight dynamics conditions. The CAD software chosen is the SolidWorks, because it is used in almost all projects nowadays. The CAE software to make the pre-processing was the HyperMesh. This one can generate one of the most confinable meshes compared to the other pre-processing softwares. To make the post-processing, the Star CCM+ software was used because of its reliability in fluid dynamics field simulations.

III. SIMULATION

3.1- Pre-Processing

To make the pre-processing was used a shell geometry, and was chosen to used r-trias elements because of the geometry of the models. The mesh was more refined at the leading edge and in the trailing edge, as like as in the wing tip.

3.2- Post-Processing

Done the final mesh, it have been imported to Star CCM+, and begin the simulation. We have made a spherical wind tunnel to simulatea flight condition, and applied some inputs, like velocity, density and turbulence. After the simulation, the obtained lift coefficient, the drag coefficient, the drag, the lift and the vortex lines of the both models, and the registers were compared the both results.

IV. MATHEMATICAL MODELING

We chose to consider the aircraft body and wing as a big wing, then we measure the span of the model in SolidWorks, and calculate the area of the aircraft as a trapezoidal wing, where S is the area, cr is the root chord, ct is the tip chord and b is the span (1).

(1) $S = \sum \frac{(cr+ct)b}{2}$

With the wing area, we can calculate the aspect ratio of the aircraft (2).

(2) $AR = \frac{b^2}{S}$

Now, it is possible to obtain the Oswald's efficiency (3), and then calculate the induced drag coefficient (4).

(3) $e = 1.78(1 - 0.045AR^{0.68}) - 0.64$

(4) $C_{Di} = \frac{C_L^2}{\pi.AR.e}$

Finally, we can estimate the Induced Drag (5) with the following equation, where ρ is the air density at cruise flight, and we consider the aircraft flight at 0.85 Mach:

(5) $D_i = \frac{1}{2}\rho.V^2.S.C_{Di}$

The reduce of induced drag with winglet

(6) $100 - (\frac{D_i(winglet).100}{D_i(without\ winglet)})$

V. RESULTS

At the simulation, we consider a cruise flight at 0.85 Mach, and obtain the result below:

Table. 1: Simulation results

	C_D	C_L	Lift (N)	Drag (N)
Without Winglet	0.013951578	0.4007020	2993774	104236.54
Winglet	0.013160766	0.4096124	3193054	102592.18

In addition, with all the calculations we obtain the following results:

Table.2: Equations results

	C_{Di}	Induced Drag (N)
Without Winglet	0.007498	68941.8486
Winglet	0.006988	65259.17658

Table.3: Winglet efficiency at induced drag

Winglet efficiency (%)	5.341707679

The vortex simulation demonstrate that the aircraft with winglets have a higher reduce in the vortex generation, increasing the aircraft stability and helping the controllability.

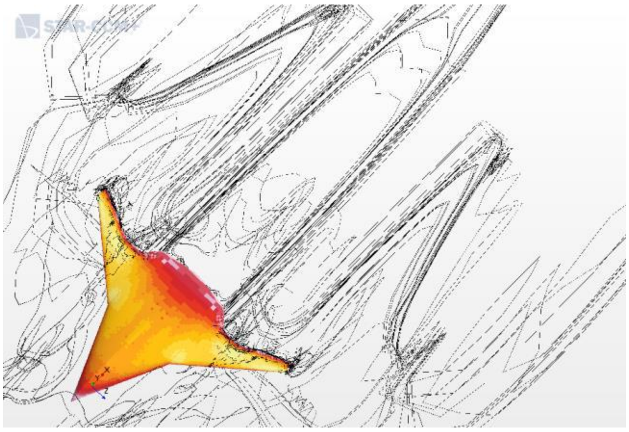

Fig. 2: Model without winglet vorticity

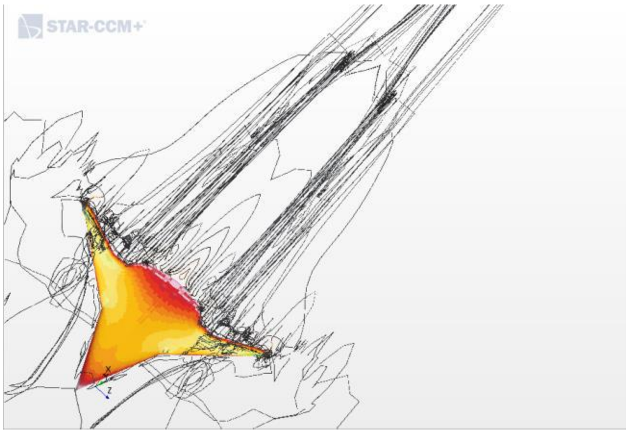

Fig. 3: Model with winglet vorticity

VI. CONCLUSION

With this results we can conclude that the winglet model have less Induced Drag, Drag coefficient, total Drag and an increase of Lift and Lift coefficient. The winglet aircraft also have the vortex reduced. Therefore, the winglet is a great choice to improve the aircraft flight conditions.

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REFERENCES

[1] Anderson, J. D. (2001). Fundamentals of aerodynamics. Boston: Mc-Graw Hill.
[2] Gudmundsson, S. (2016). General aviation aircraft design: Applied methods and procedures. Amsterdam: Butterworth-Heinemann.
[3] Ikeda, T. (2006). Aerodynamic analysis of a blended-wing-body aircraft configuration. Melbourne, VIC: RMIT University.
[4] Hossain, A., Rahman, A., Hossen, J., Iqbal, A., & Zahirul, M. (2011). Prediction of aerodynamic characteristics of an aircraft model with and without winglet using fuzzy logic technique. Aerospace Science and Technology, 15(8), 595-605. doi:10.1016/j.ast.2010.12.003
[5] Narayan, G., & John, B. (2016). Effect of winglets induced tip vortex structure on the performance of subsonic wings. Aerospace Science and Technology, 58, 328-340. doi:10.1016/j.ast.2016.08.031
[6] Qin, N., Vavalle, A., Moigne, A. L., Laban, M., Hackett, K., & Weinerfelt, P. (2004). Aerodynamic considerations of blended wing body aircraft. Progress in Aerospace Sciences, 40(6), 321-343. doi:10.1016/j.paerosci.2004.08.001
[7] Raymer, D. P. (2012). Aircraft design: A conceptual approach. Reston, VA: American Institute of Aeronautics and Astronautics.
[8] Yu, J., Wang, L., & Gao, G. (2006). Using Wing Tip Devices to Improve Performance of Saucer-Shaped Aircraft. Chinese Journal of Aeronautics, 19(4), 309-314. doi:10.1016/s1000-9361(11)60333-6