

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 2, February 2020

Fabrication and Analysis of Aircraft Winglet

Silan Wilson Satish¹, Yadav Suresh Sivan², B.Vivek³, T.Subash⁴, J.Arthur Jebaraj¹, K.Robinston Jeyasingh²

Final year Students, Department of Mechanical Engineering, Francis Xavier Engineering College, Tirunelveli,
Tamil Nadu, India ¹

Professor, Department of Mechanical Engineering, Francis Xavier Engineering College, Tirunelveli,
Tamil Nadu, India ²

ABSTRACT: Observers have always been fascinated by soaring birds. An interesting feature of these birds is the existence of few feathers extending from the tip of the wing. In this paper, small lifting surfaces were fitted to the tip of a NACA0015 wing in a fashion similar to that of wing tip feathers. Experimental measurements of induced drag, longitudinal static stability and trailing vortex structure were obtained. The tests showed that adding wing tip surfaces (sails) decreased the induced drag factor and increased the longitudinal static stability. Results identified two discrete oppositely rotated tip vortices and showed the ability of wing tip surfaces to break them down and to diffuse them.

KEYWORDS: Wing tip sails, Induced drag, Wing tip vortices.

I. INTRODUCTION

Studies made of the flow about the wing tip of a wind tunnel model showed that the vortex-type flow generally associated with the rolled-up vortex sheet well behind the wing tip existed just behind the trailing edge and seemed to be forming over the top of the wing tip itself [1]. Since lift generated by a finite wing could be explained only by a circulatory flow generated by the proper vortex strength, a properly placed vortex filament could simulate the wing. Prandtl called this vortex a lifting line. It is also known as the bound vortex [2]. The bound vortex could not just disappear when the lift dropped to zero at the wings' tips but it would continue into the fluid and produce actual free vortex in the fluid at the tips of the wing. These tip vortices trailing behind present day's aircraft are of great concern to the aviation community because they may be hazardous to a trailing aircraft and they are responsible for creating a drag component known as induced drag or lift dependent drag [3]. For most transport aircraft, induced drag is approximately 30% of total drag in cruise and more at lower speeds [4]. Wing tip sails are small lifting surfaces fitted to the wing in such a way that they use the local air flows about the wing tip to produce a thrust. They act in a manner similar to that of the sail of a yacht when it is sailing close to the wind, hence their name [5] and they are inspired by the birds' wing tip feathers as shown in figure below:

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 2, February 2020



II. THE DESIGN PROCESS

The start of the design process requires the recognition of a 'need'. This normally comes from a 'project brief' or a 'request for proposal' (RFP). Such document comes from various sources.

- ✓ Established or potential customers.
- ✓ Government defines agencies.
- ✓ Analysis of the market and the corresponding trends from aircraft demand.
- ✓ Development of an existing product.
- ✓ Exploration of new technology and other innovations research and development.

Therefore, wingtip vortex will be analyzed and we may check how the vortices magnitude can be reduced with winglets.

Finally, a winglet will be chosen due to drag coefficient's reduction when that winglet will be working at the wingtip. Furthermore, as this winglet has been previously picked, I will make a point linked to it, and the drag coefficient reduction will be showed in a final table.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 2, February 2020

III. PRINCIPLES

Drag force is the summation of all forces that resist against aircraft motion. The estimation of the drag of a complete airplane is a difficult and challenging task, even for the simplest configurations. We will consider the separate sources of drag that contribute to the total drag of an aircraft. The real shape of drag force as a function of speed is parabola. It means that there are some parameters that will decrease drag as the velocity increases and there are some other parameters that will increase drag as the velocity increases. This observation shows us a good direction for drag classification. Although the drag and the drag coefficient can be expressed in a number of ways, for reasons of simplicity and clarity, the parabolic drag polar will be used in all main analyses. Different references and books use different terminology, so it may confuse students and engineers. In this section, a list of definitions of various types of drag is presented, and then a classification of all of these drag forces is described.

Induced Drag: The drag that results from the generation of a trailing vortex system downstream of a lifting surface of finite aspect ratio.

Parasite Drag: The total drag of an airplane minus the induced drag. Thus, it is the drag not directly associated with the production of lift. The parasite drag is composed of many drag components, the definitions of which follow

Skin Friction Drag: The drag on a body resulting from viscous shearing stresses over its wetted surface. Frequently, the drag of a very streamlined shape such as a thin, flat plate is expressed in terms of a skin friction drag. This drag is a function of Reynolds number. There are mainly two cases where the flow in the boundary layer is entirely laminar or entirely turbulent over the plate.

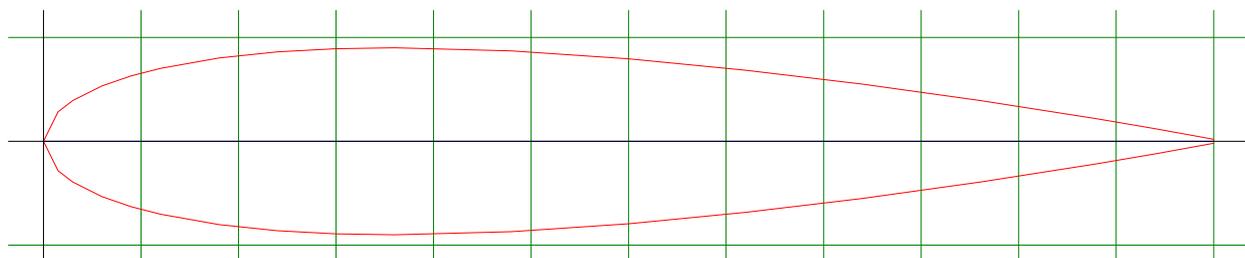
Form Drag (sometimes called **Pressure Drag**): The drag on a body resulting from the integrated effect of the static pressure acting normal to its surface resolved in the drag direction. Unlike the skin friction drag that results from viscous shearing forces tangential to a body's surface, form drag results from the distribution of pressure normal to the body's surface.

Trim Drag: The increment in drag resulting from the aerodynamic forces required to trim the airplane about its center of gravity. Usually this takes the form of added induced and form drag on the horizontal tail.

Profile Drag: Usually taken to mean the total of the skin friction drag and form drag for a two-dimensional airfoil section.

AIRFOIL DATA

We are using NACA0015 symmetrical airfoils with the given below dimensions. In this airfoil the sails is to be mounted with the same airfoil symmetrical data.



Name = NACA 0015 Chord = 120mm, Radius = 0mm, Thickness = 100 ORIGIN = 0%, PITCH = 0

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 2, February 2020

IV. RESULTS

a) Test Conditions

The aircraft model tests with different configuration of winglets and without winglet were carried out at Reynolds numbers 1.7×10^5 , 2.1×10^5 , and 2.5×10^5 . The measured values for the lift force, and drag force for the various configurations were given in Ref. [16-17] and coefficient of lift and coefficient of drag were calculated as per the procedures explained.

b) Coefficient of Lift

The coefficient of lift versus angle of attack for the aircraft wing model with and without winglet studied in the present investigation are shown in Fig. 7 for the maximum Reynolds number of 2.5×10^5 . 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.

c) Coefficient of Drag

The drag coefficients of the aircraft wing model under test for all Reynolds numbers are shown in Fig. 8. From the graph, it is observed that the drag coefficient for the aircraft wing model measured under all the configurations under this study shows an increasing trend with angle of attack for a Reynolds number 0.25×10^6 . 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.

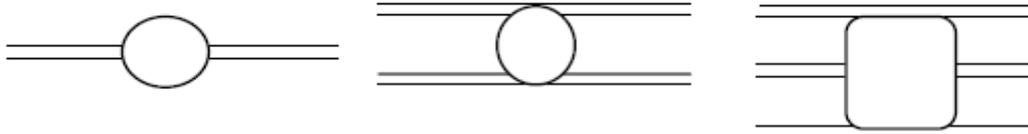
The rapid increase in drag coefficient, which occurs at higher values of angle of attack, is probably due to the increasing region of separated flow over the wing surface, which creates a large pressure drag. From the figure it is observed that the values of the minimum drag coefficients are 0.067, 0.053, and 0.052 respectively for different configurations for the maximum Reynolds number of 2.5×10^5 which occur at zero angle of attack. In particular the measured drag values against the angle of attack are minimum for the winglet of configuration 1 and 2 over

V. WING CONFIGURATION

In general, wing configuration alternatives from eight different aspects are as follows:

❖ Number of wing

1. Monoplane
2. Biplane
3. Trip lane



1. Monoplane

2. Biplane

3. Tri-plane

Figure-3.1: Number of wings

International Journal of Innovative Research in Science, Engineering and Technology

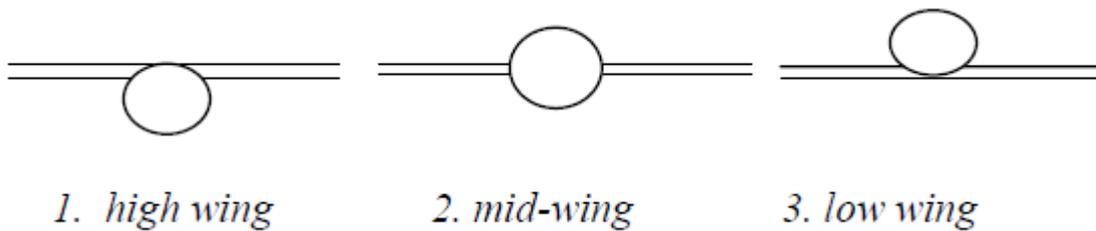
(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 2, February 2020

❖ Wing location

1. High wing
2. Mid wing
3. Low wing
4. Parasol wing



Wing location

Figure-3.2:

❖ Wing type

1. Rectangular
2. Tapered
3. Delta
4. Swept back
5. Swept forward
6. Elliptical

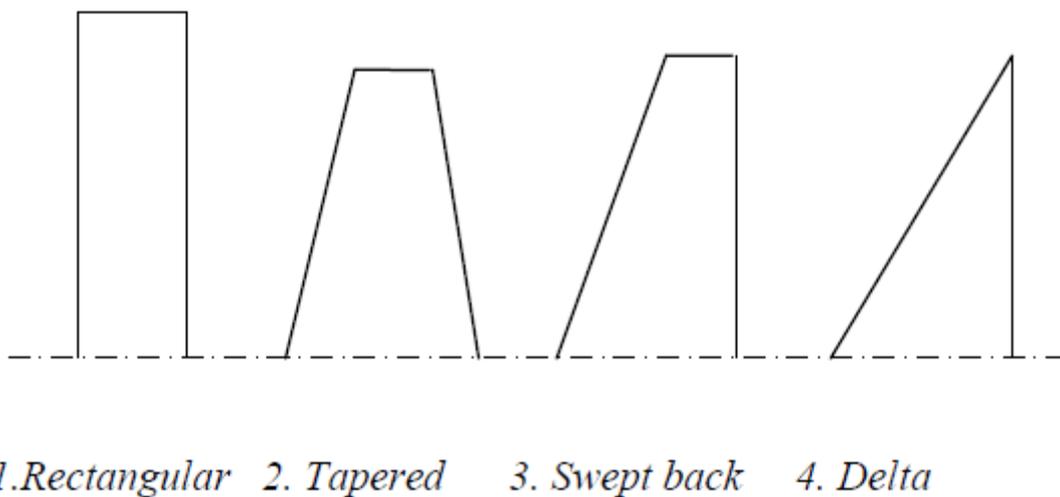


Figure-3.3: Wing type

❖ High lift device

1. Plain flap
2. Split flap

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 2, February 2020

3. Slotted flap
4. Kruger flap
5. Double slotted flap

❖ Sweep configuration

1. Fixed wing
2. Variable sweep

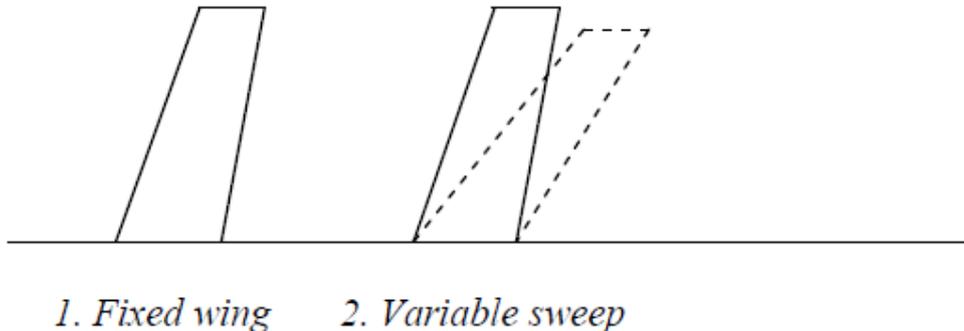


Figure-3.4: Sweep configuration

❖ Shape

1. Fixed shape
2. Morphing wing

❖ Structural configuration

1. Cantilever
2. Strut-braced (a. faired, b. un-faired)
3. Wire braced

VI. CONCLUSION

Wind tunnel tests have shown that the drag of a wing can be reduced over a considerable lift range if wing tip sails are fitted to the tip of a planar wing. Sails fitted to the wing tip can reduce its lift dependent drag by up to 35%. An increase in local angle of attack of the sails, and also an increase in the number of sails decreases the lift dependent drag, while the increase of number of sails decreases it also.

Longitudinal static stability of the wing was significantly improved after adding the sails. The amount of longitudinal static stability was increased by decreasing the local angle of attack of the sails, increasing the number of sails and moving a sail backward toward the winglet's trailing edge.

REFERENCES

1. B.W. McCormick, Aerodynamics of V/STOL Flight. Academic Press, London, 1967.
J. D. Anderson, Introduction to Flight, McGraw-Hill Companies, Inc., United States of America.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 2, February 2020

3. R.T.Whitcomb, A Design Approach and Selected Wind-Tunnel Results at High Subsonic Speeds for Wing-Tip Mounted Winglets, NASA TN D-8260, 1976.
4. R. T. Whitcomb, Methods for Reducing Aerodynamic Drag, NASA Conference Publication 2211, Proceedings of Dryden Symposium, Edwards, California, 1981. R. T. Jones, Improving the Efficiency of Smaller Transport Aircraft,
5. M. D. Maughmer, S. S. Timothy, and S. M. Willits, The Design and Testing of a Winglet Airfoil for Low-Speed Aircraft, AIAA Paper 2001-2478, 2001,
6. J. J. Spillman, The use of wing tip sails to reduce vortex drag, Aeronautical Journal, September, pp. 387-395, 1978.
7. J. J. Spillman, H. Y. Ratcliffe, and A. McVitie, Flight experiments to evaluate the effect of wing-tip sails on fuel consumption and handling characteristics, Aeronautical Journal, July, pp. 279-281, 1979.
8. J. J. Spillman, and M. J. Fell, The effects of wing tip devices on (a) the performance of the Bae Jetstream (b) the far-field wake of
9. a Paris Aircraft, Paper 31A, AGARD CP No. 342, Aerodynamics of Vertical Type Flows in Three Dimensions.
10. A.T. Vance, Gliding Birds: Reduction of Induced Drag
11. by Wing Tip Slots between the Primary Feathers, Journal of Experimental Biology, Vol. 180 (1), pp. 285-310, 1993.
12. M. J. Smith, N. Komerath, R. Ames, O. Wong, and J. Pearson, Performance Analysis of a Wing with Multiple Winglets, AIAA Paper-2001-2407, 2001.
13. L. U. Roche, and S. Palffy, WING-GRID, a Novel Device for Reduction of Induced Drag on Wings, Proceedings of ICAS 96, Sorrento, September, 1996.
14. A.J. Bocci, Wing W4 fitted with a winglet: winglet design and preliminary test results, Aircraft Research Association, ARA/M-230, 1981.
15. Kroo, and M. Takai, A Quasi-Procedural Knowledge-Based System for Aircraft Design, AIAA Paper.