

DESIGN & ANALYSIS OF AIRCRAFT BLENDED WINGLET

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Abstract -Aircraft winglet is a part placed at a set of angles on the end of aircraft wing. This part plays a very important role in improving aircraft performance. The rise in cost of the aircraft flight makes the aircraft designer and the airline management to find a new technology to reduce the cost. After many research and study in this field, it has been noted that, incorporating a winglet will be the best way to reduce cost. The presence of winglet will reduce the fuel consumption by reducing the aircraft drag and make the aircraft more stable during flight. In addition, it will give the aircraft engine longer life by reducing the load on the engine thrust. The aim of this work is to design and analyse a model of winglet for aircraft. A blended winglet is chosen and is attached to the wing with smooth curve instead of a sharp angle and is intended to reduce interference drag. The modeling and analysis of the winglet has been done using softwares such as CATIA -V5 and ANSYS. Air flow analysis is being carried out in the fluent module of the ANSYS workbench and it has been found that the velocity of the air flow across the wing with winglet design doesnot cause any harm or stress to the winglets. Thus the induced drag is also reduced improving the performance of the take off.

Keywords: aircraft, induced drag, take-off, velocity of air flow, winglet

I. INTRODUCTION

The main motivation for using wingtip devices is reduction of lift-induced drag force. Environmental issues and rising operational costs have forced industry to improve the efficiency of commercial air transport and this has led to some innovative developments for reducing lift-induced drag. Several different types of wingtip devices have been developed during this quest for efficiency and the selection of wingtip device depends on the specific situation and airplane type. Commercial passenger aircrafts spend most of their operational life at cruise condition, thus all wingtip shapes need to be examined in those conditions in order to justify their purpose. Winglets allow for significant improvements in the aircraft fuel efficiency, range, stability, and even control and handling. They are traditionally considered to be near-vertical, wing-like surfaces that can extend both above and below the wing tip where they are placed. Some

designs have demonstrated impressive results, like 7 percent gains in lift-to-drag ratio and a 20 percent reduction in drag due to lift at cruise conditions. The concept of winglets was originally developed in the late 1800s by British aerodynamicist Frederick W. Lanchester, who patented an idea that a vertical surface (end plate) at the wingtip would reduce drag by controlling wingtip vortices. Unfortunately the concept never demonstrated its effectiveness in practice because the increase in drag due to skin friction and flow separation outweighed any lift-induced drag benefit. Long after Frederick W. Lanchester, engineers at NASA Langley Research Centre inspired by an article in Science Magazine on the flight characteristics of soaring birds and their use of tip feathers to control flight, continued on the quest to reduce induced drag and improve aircraft performance and further develop the concept of winglets in the late 1970s. This research provided a fundamental knowledge and design approach required for

extremely attractive option to improve aerodynamic efficiency of civilian aircraft, reducing their fuel consumption and increasing operating range.

Aircraft design being a complex process has many phases in which Computer Aided Design (CAD) plays a significant role. Many aircraft manufacturers such as Boeing, Dassault, and Airbus have been adopting the CAD software tool like CATIA in order to minimize the lead time and to avoid prolonged duration in design process. CAD combined with Knowledge based engineering (KBE) aimed at reducing time taken for design process in case of repetition. Studies have been done on developing parameterized CAD models focusing to optimize the given model with less duration of time. D operator and K operator were the two approaches developed with CAE tools for making repetitive process. VB script is associated with D operator, whereas Knowledge Pattern (KP) developed based on C++ programming language, is under the K operator approach. KP has been implemented in Dassault systems software CATIA V5 R16. One of the main disadvantages in VB script for dynamic instantiation of the models is longer time consumption for scripting. Studies revealed that automation for creating models and patterns dynamically were done based on Knowledge Pattern script where the time consumed for pattern creation and scripting were much lesser than VB approach.

II. LITERATURE REVIEW

History of Wingtip devices and Winglets

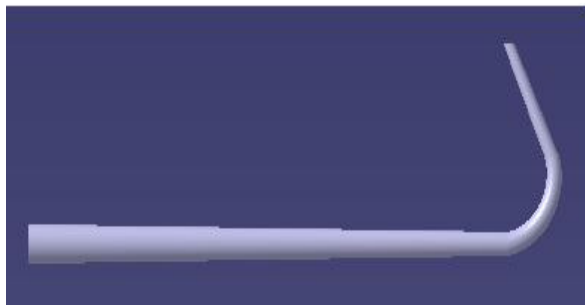
Endplate theory was the first to propose wingtip device and was patented by Fredrick W. Lanchester, British Aerodynamicist in 1897. Unfortunately, his theory could not reduce the overall drag of aircraft despite reducing the induced drag. The increase in the viscous drag during cruise conditions outruns the reduction in induced drag. In July 1976, Dr. Whitcomb made a research at NASA Langley research center and developed the

concept of winglet technology. According to Whitcomb, winglet could be described as the small wing like vertical structures which extends from the wingtip, aiming at reduction in induced drag when compared to other wing tip devices or extensions. He also claimed in his research that the winglet shows 20% reduction in induced drag when compared to tip extension and also improved lift-to-drag ratio.

In 1994 Aviation Partners Inc. (API) developed an advance design of winglet called blended winglet. Louis B. Gratzner from Seattle has the patent for blended winglet and intention of the winglet is to reduce the interference drag due to sharp edges as seen in the Whitcomb's winglet. Also, Gratzner has the patent for the invention of spiroid-tipped wing in April 7, 1992. Later, "wing grid" concept was developed by La Roche from Switzerland in 1996 and got the patent for his invention. The main purpose of all the above inventions was to decrease the strength of wake vortex and to reduce induced drag.

III. DESIGN OF SOLID WINGLET

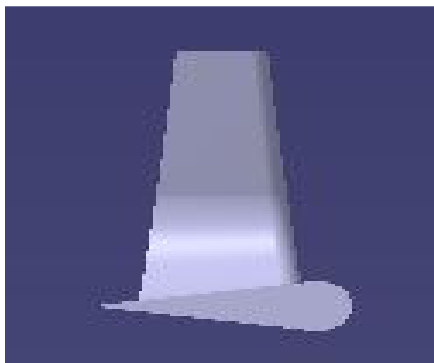
A blended winglet was attached to the wing tip with a smooth curve instead of a sharp angle which was intended to reduce interference drag at the wing/winglet junction. A sharp interior angle in this region can interact with the boundary layer flow causing a drag inducing vortex, negating some of the benefits of the winglet. Such blended winglets are used on business jets and sailplanes, where individual buyer preference is an important marketing aspect. Blended winglet used in this work.



Front View

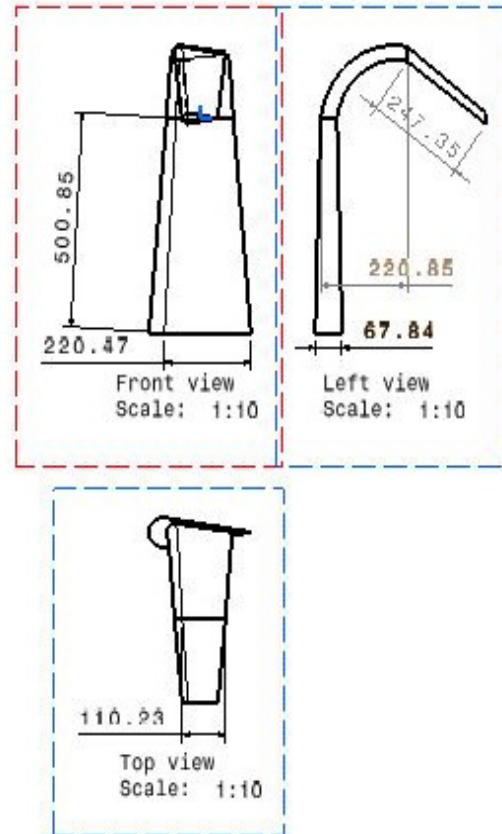


Top View



Left View

Geometric View:



Dimensions of winglet:

Sweep Radius = 247.35 mm

Vertical Length = 500.85 mm

Leading Edge Length = 220.47 mm

IV ANALYSIS OF WINGLET

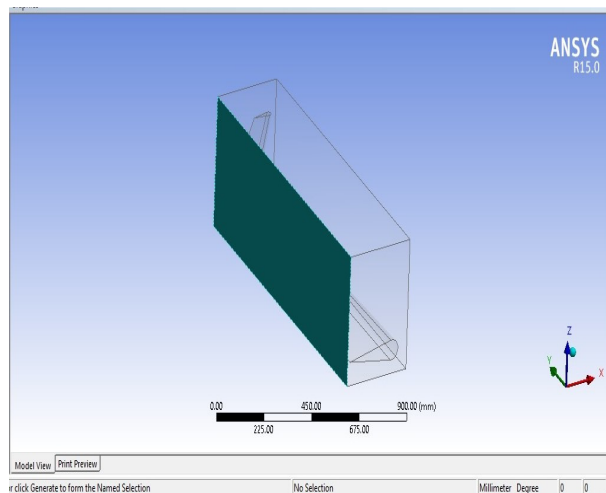
ANSYS -14.0 (CFD) is used to test and simulate the winglet model in two different speeds at 150 Km/hour as take-off speed and 300 Km/hour as cruise speed.

Some pre design setting requirements on the software are:

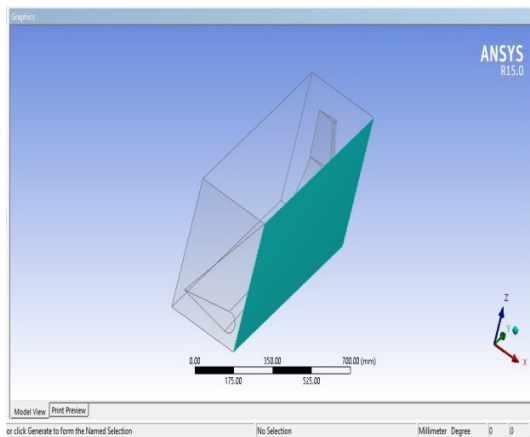
- ❖ Using Air flow
- ❖ Save as IGS

- ❖ Geometry-mm dimension
- ❖ File-import from CATIA as geometry file
- ❖ Using mesh tool –Air Flow Launcher

Blended winglet is to be inlet in the ANSYS, it has capacity to withstand the air with the velocity upto 50 m/s.



Inlet 1



Inlet 2

MESHING:

The meshing is carried out for winglet in the workbench and unstructured tetra elements are selected for these computations. As per the boundary layer calculation, boundary layer thickness is calculated as 10.4 mm and Reynolds

number as 7, 23,670 (for the Aircraft speed 50m/s). 12 layers are used inside the boundary layer for both the cases. Select all the surface required to carry the mesh.

The mesh details of the as follows:

Table : Meshing

Element type	Unstructured Tetra elements
Total elements	2757733
Total nodes	491323
Geometry	Dimension
Physics Preference	CFD
Solver Preference	Fluent

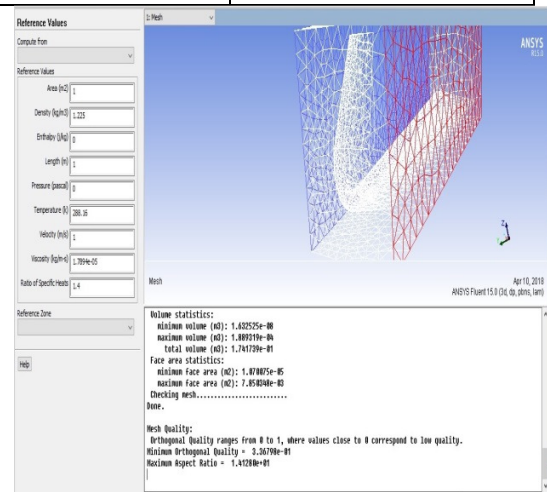


Figure 3.7 Mesh 1

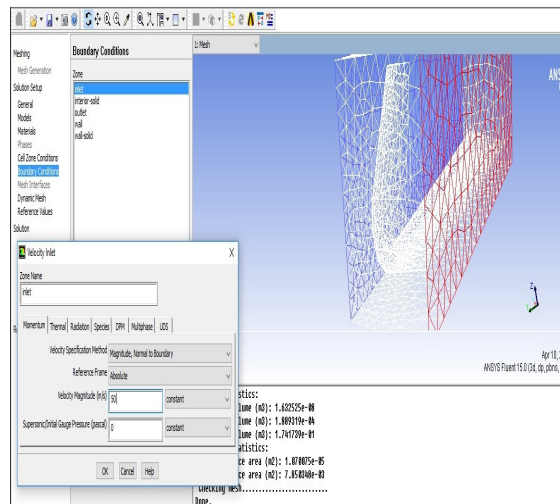


Figure 3.8 Mesh 2

Boundary condition:

Table : Boundary condition

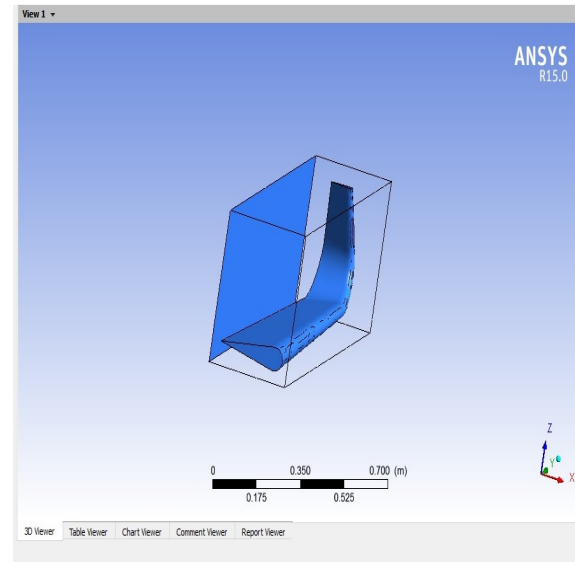


Figure Outlet

V. RESULTS AND DISCUSSION

Analysis Solution – Velocity

In the ANSYS software the blended winglet is to be analysed in work bench – fluent module.

The green region of the streamline indicates the harmfree zone. The green bubbles indicates safe air flow. Thus from analysis, it is clear that due to the use of winglet the coefficient of drag is reduced, which helps the increasing performance of aircraft.

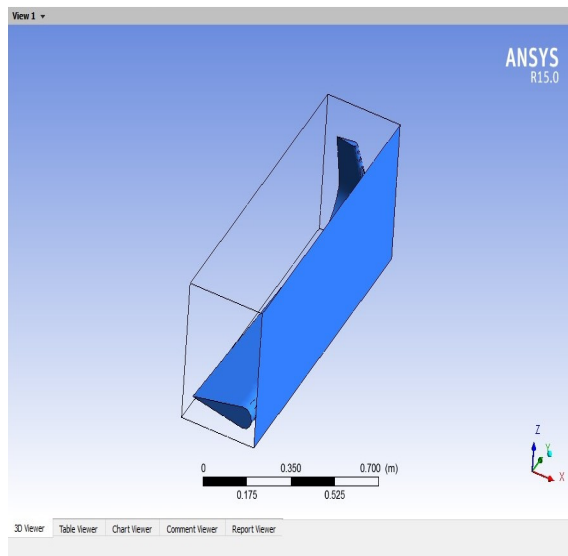


Figure Outlet 1

Component	Boundary type
Inflow	Velocity Boundary (50m/s)
Outflow	Pressure Outlet
Aircraft	Wall
Far field	Slip
Symmetry	Symmetry option

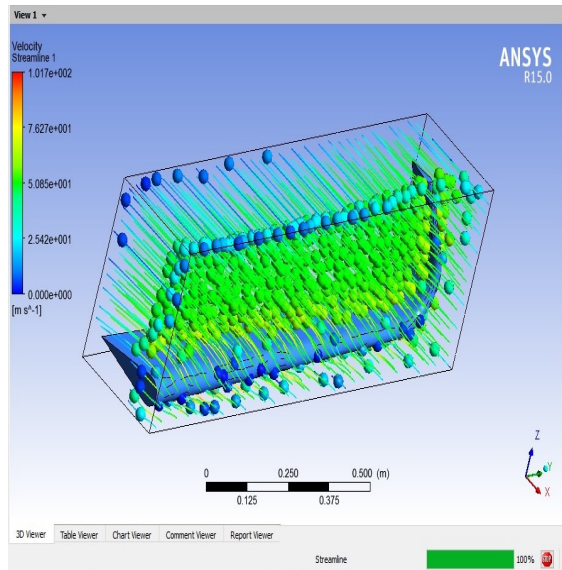


Figure Velocity 1

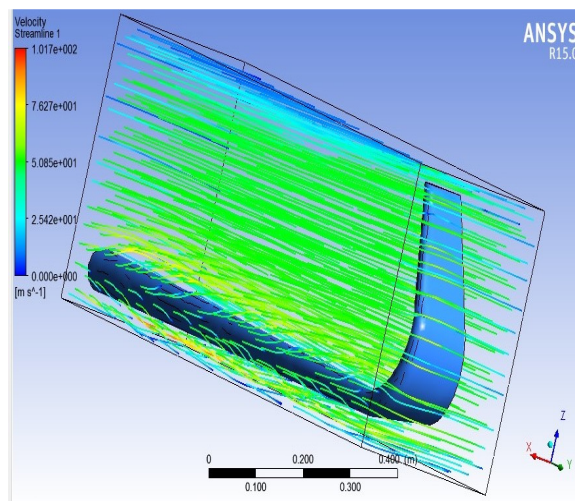


Figure Velocity 2

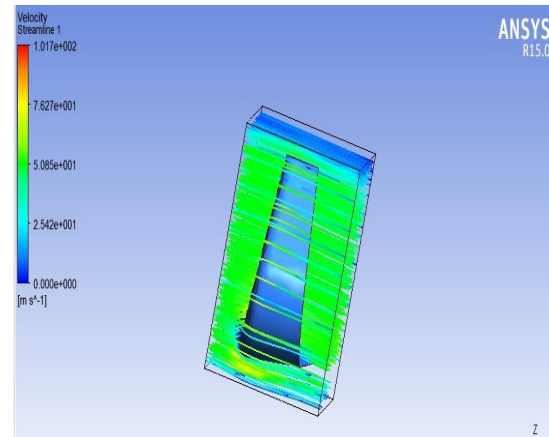


Figure Velocity 3

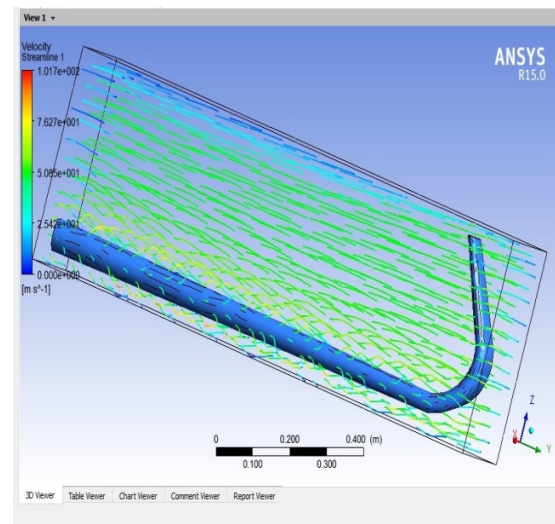


Figure Velocity 4

VI. CONCLUSION

From the study of different types of winglet devices and analysis of their contribution in aircraft performance, it is understood that the winglet is the good technology to improve the aircraft performance in term of less fuel consumption. The winglet will reduce the use of aircraft engine at high power so the engine life will be increased. Winglet will increase the angle of attack very quickly during take-off and the aircraft will reach its altitude faster than aircraft without winglet. This will lead to lower engine thrust

which inturn low maintenance is required. The effect of winglet is high in terms of fuel consumption due to less drag on aircraft body so, less amount of fuel is required. This also helps in increasing the range of the aircraft. This will make the aircraft use less fuel resulting in longer flight range without the need of refueling which will be benefit for the aircraft operator in two ways. Lot of parameters like aircraft size, its weight during take off, type of wing fitted and so on affect the design of winglet. In this work, the design has been made by using CATIA-V5 software. ANSYS software is used for CFD AIR FLOW analysis . From all the above result it can be concluded that the winglet device is a good technology to enhance the aircraft performance in terms of less fuel consumption, more stable cruise flight, less engine load during tack off by reaching the require altitude faster than aircraft without winglet.

[7] Molnar, M: Boeing Says Radical New Winglets on 737 MAX Will Save More Fuel/ NYC Aviation. Retrieved 3 May 2012.

[8] ANSYS Fluent 14.5: User's guide, ANSYS, Inc.,Canonsburg, PA, 2013.

[10] <http://www.winggrid.ch/2014>.

REFERENCES

[1] R.T. Whitcomb, "A Design Approach and Selected Wing-Tunnel Result at High Subsonic Speed for Wing-Tip Mounted Winglets," NASA TN D-8260, 1976, USA.

[2] R. T. Jones and T. A. Lasinski, "Effect of Winglets on the Induced Drag of Ideal Wing Shapes," NASA TM-81230, 1980, USA.

[3] L. B. Gratzler, "Blended winglet," 1994.

[4] McLean, D., "Wingtip Devices: What They Do and How They Do It" presented at the Boeing Performance and Flight Operations Engineering Conference, 2005.

[5] Lambert, D., "Numerical Investigation of Blended Winglet Effects on Wing Performances, report" Liege University; 2007.

[6] J. Mohammed, et al., "Applications of Computer Aided Design (CAD) In Knowledge Based Engineering," Proceedings of the 2008 IAJC-IJME International Conference, 2008.