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Study of Aerodynamic Characteristics of a Spiroid Winglet

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Abstract – In this paper the effect of spiroid winglet on aerodynamic efficiency was investigated. A sweptback and tapered wing with NACA 0015 airfoil section was considered as base geometry. Above wing is modified by providing spiroid winglet at the tip of wing. Velocity of 35 m/s was taken to simulate this. CFD code was use to carry out the computation. The simulated results were compared with experimental result to validate the CFD code. In this process tangential velocity, lift coefficient and drag coefficient were computed initially. The simulations obtained from the CFD code show a very good agreement with the experimental results. The aerodynamics parameters were calculated at different geometric angle of attack (4°, 8°, 12° and 16°) . The numerical results were compared with the result of base line model to find out the effect of spiroid winglet. It was observed the drag is reduced by using spiroid winglet.

Keywords: Tip-vortex, Spiroid winglet, Drag, Wingtip, Induced drag

I. Introduction

In aeronautical engineering, drag of aircraft is a major parameter for performance of aircraft. There is always a opportunity to reduce the drag and increase the aerodynamic efficiency in aerospace industry. Mainly a three dimensional lifting surface will produce parasite drag and induced drag in subsonic flow. There are many technique available to reduce the parasite drag in fluid dynamics. Here an attempt was taken to find out the effect of spiroid winglet on drag reduction.

The induced drag is directly proportional to the downwash. So the induced drag or lift-induced drag can be reduced by decreasing the down wash. Lif to drag ratio is known as aerodynamic efficiency.

To improve the aerodynamic efficiency lift to drag ratio need to be improved. So we can increase lift keeping drag as constant or decrease drag keeping lift as constant. Typically induced drag is 30% more at time of cruising time [1]. This is more at subsonic flight. We can save lot of fuel by reducing small amount of drag [2]. It was estimated total flight in world is 17 thousand aircrafts [3]. The induce drag is more in low speed. This may happen during takeoff and landing time. At this time induced drag is account for 80-90% of the aircraft drag [4].

There are many technique available to reduce the lift-induce drag. There are so many methods to reduce the wing tip vortex, which creates the lift-induced drag. Wingtip devices is one of the option to reduce lift-induced drag. Generally this is ude to reduce the using wingtip devices. By reducing the tip vortex or induced drag, the aerodynamic efficiency is increased. There are many different types of tip devices. All different device function in different way. But the aim of this tip device is to reduce the induced drag by partial recovering the energy from vortex. By providing more span would result in lower induced drag. But the parasite drag can increase due to more span length. This will cause to increase weight. So it may not provide net benefit. Also there is some limitation on span length due to operational condition. By reducing the drag causes to improve fuel efficiency.

In this work spiroid wingtip was taken one of the wingtip device to see the impact on induced drag. Spiroid wingtips device is an extended blended wingtip that bends upward by 360 degrees to form a large rigid ribbon. Diferent aerodynamic parameters were simulated for spiroid wingtip wind and compared with base geometry.

II. Procedure

The Fluent was used to simulate the fluid flow around the wing. Using CFD many complex geometry and complex flow can be simulated.

Initial model was swept back. This geometry was tapered and untwisted wing. The AR ratio was 3.65. The taper ratio was 0.37 and semi-span length was 51 cm. The wing are was 713 cm2 (Fig. 1). NACA 0015 airfoil section was taken throughout the wing span.

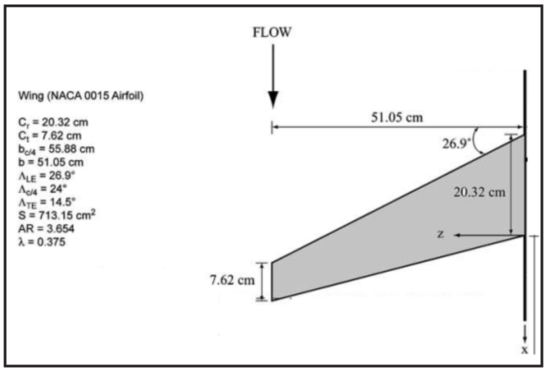

Fig. 1. Initial model configuration (Swept back wing)

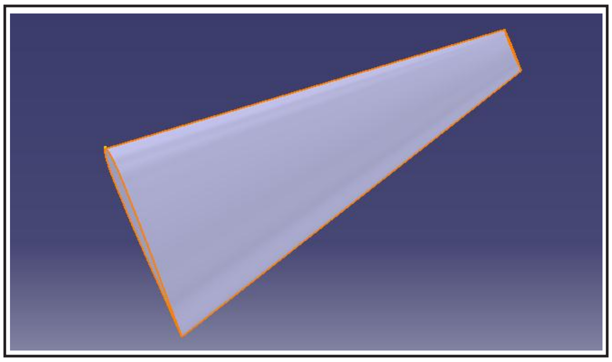

Fig. 2. Base line geometry configuration modelled in CATIA

Keeping all the geometric parameters as constant the above wing was modified to spiroid winglet wing for the interest of this reassert work. Only the tip part is modified to create spiroid winglet (Fig. 3). First the base line model was designed with CATIA V5R21 software using the above given data. Then the winglet was modified by using the rib command in the wing tip as per following dimensions.

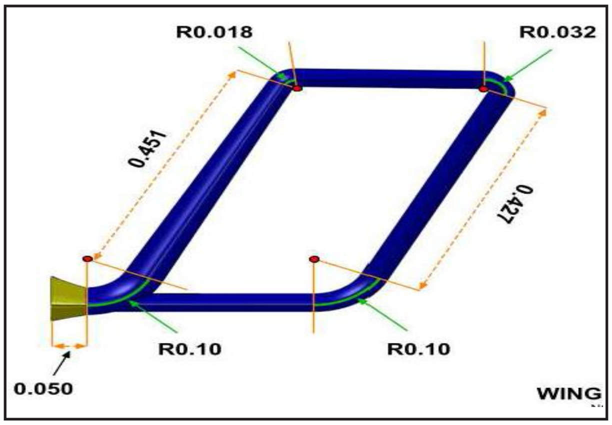

Fig. 3. Wing with spiroid winglet

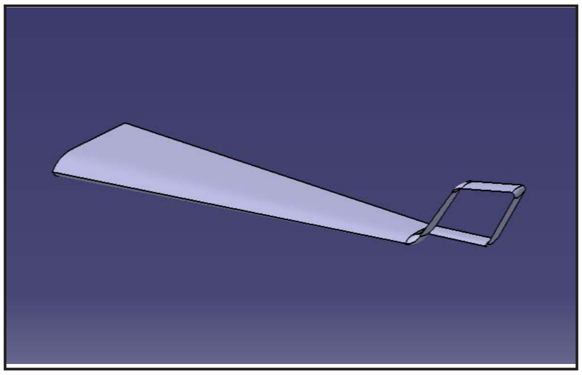

Fig. 4. Modified model with spiroid winglet from base model

III. Results and Discussion

Non-dimensional tangential velocity (v_θ/u_∞) distribution about the vortex core at 8° angle of attack and lift, drag coefficients at different angles of attack were computed at free stream velocity of 35 m/s. The simulated result are numerically computed and those value were compared with experimental results done by Gerontakos and Lee [5]. Figures 5-7 show a comparison between numerical and experimental results of v_θ/u_∞, C_L and C_D. These show good with the experimental results.

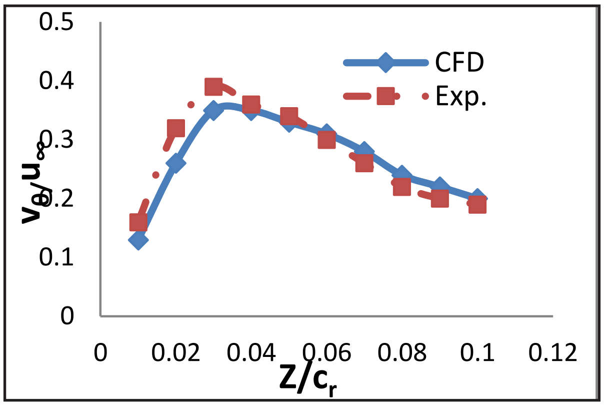

Fig. 5. Tangential velocity about the wingtip vortex

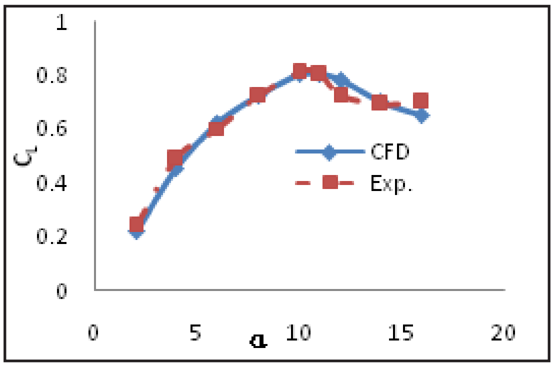

Fig. 6. Lift coefficients Vs angle of attack

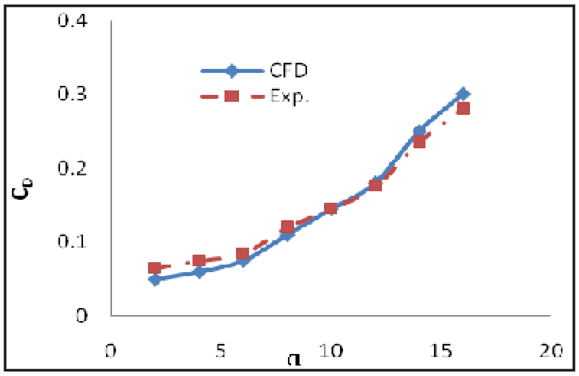

Fig. 7. Drag coefficients Vs angle of attack

The results obtained from CFD code for base line model (without winglet) is given in table-1 and for modified wing with spiroid winglet is given in table-2. The pressure distribution over the wing surface were captured and given in Fig. 8 and 9. Al the aerodynamics parameter lift coefficient, drag coefficient and aerodynamic efficiency are calculated and those parameters are ploted in Fig. 10 and 15. Figure 10 to 12 give the result for the wing without winglet and 13 to 15 with spiroid winglet. It was noticed both drag and lift coefficient decrease with spiroid winglet. Also the Aerodynamic efficiency which is major aerodynamic parameter reduce due to spiroid winglet.

TABLE 1
WING MODEL WITHOUT WINGLET

Parameters	*Angel of attack*	*Angel of attack*	*Angel of attack*	*Angle of attack*
C_L	0.154	0.323	0.425	0.545
C_D	0.0147	0.0312	0.0572	0.09341
	10.476	10.3525	7.43	5.8352

TABLE 2
WING MODEL SPIROID WINGLET

Parameters	*Angel of attack*	*Angel of attack*	*Angel of attack*	*Angle of attack*
C_L	0.1478	0.3046	0.4123	0.5367
C_D	0.014534	0.03024	0.05613	0.09267
	10.16925	10.07275	7.34544	5.79151

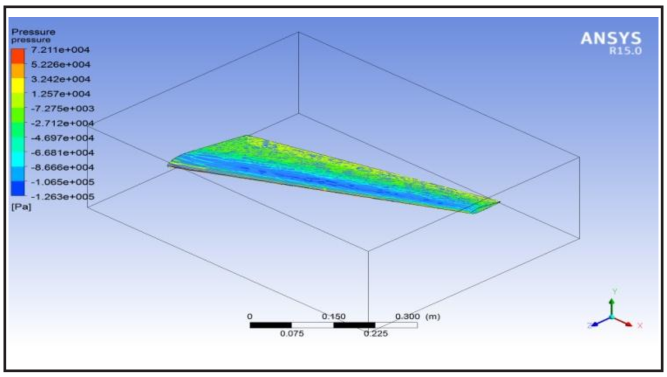

Fig. 8. Pressure over wing without winglet

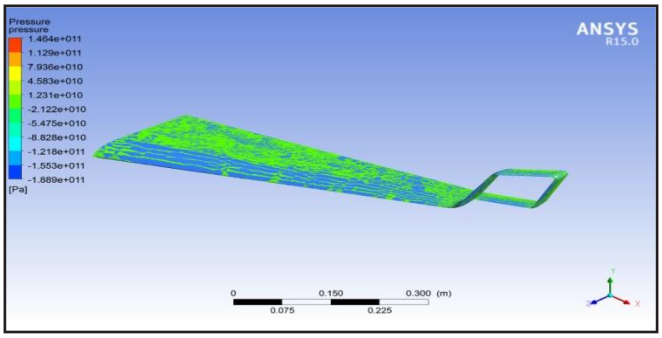

Fig. 9. Pressure over wing with spiroid winglet

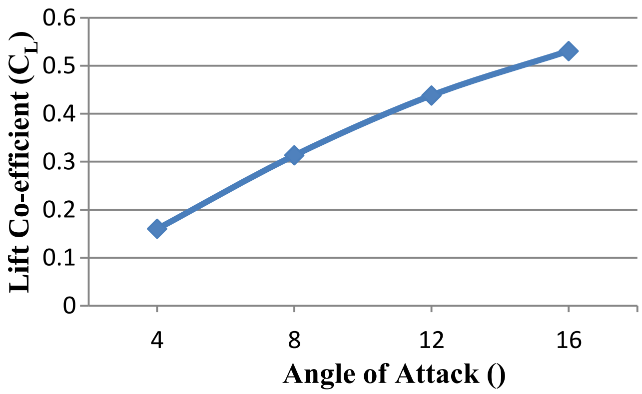

Fig. 10.   Vs α curve for without winglet

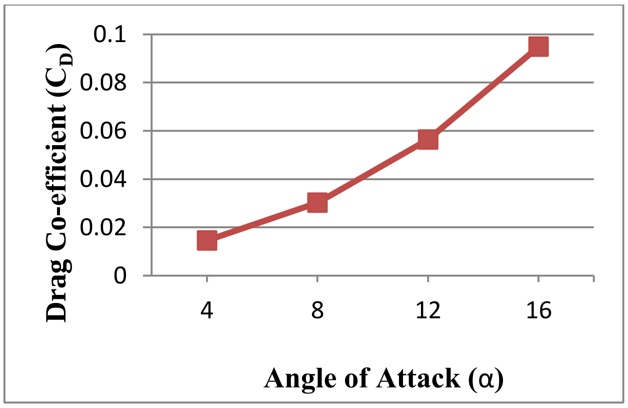

Fig. 11. Vs α curve for without winglet

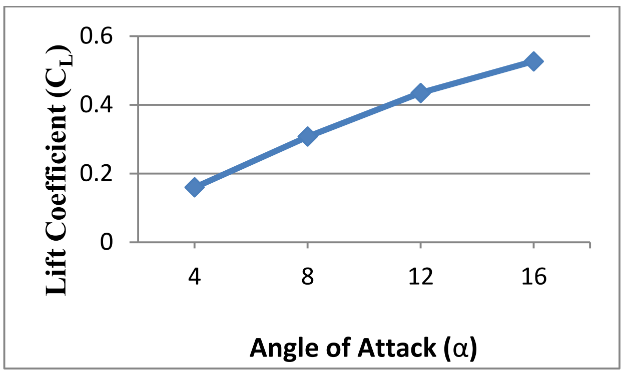

Fig. 12. C_L verses α curve for spiroid winglet model

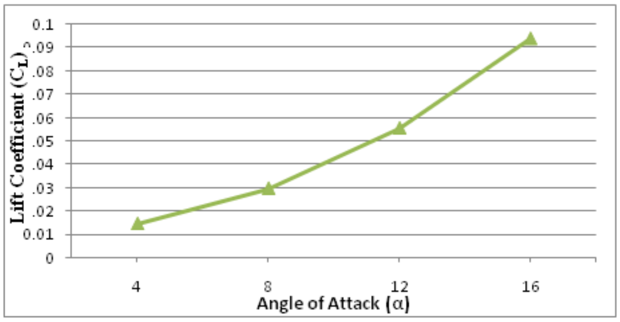

Fig. 13. C_D verses α curve for spiroid winglet model

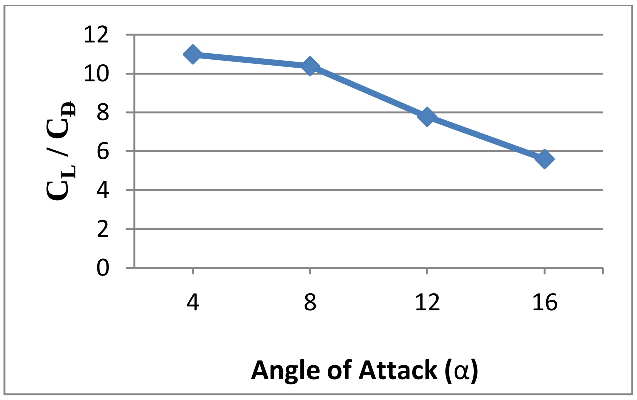

Fig. 14. Verses α curve for without winglet

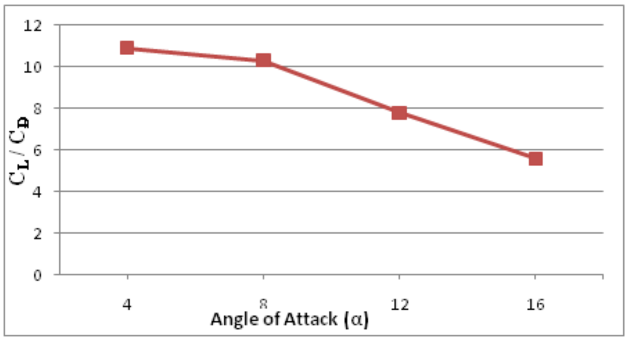

Fig. 15. Verses α curve for spiroid winglet

Conclusion

The main goal of this research work was to find out the effect of wing let (spiroid winglet) on aerodynamisc parameters. And those results were compared with the plan wing (without ant winglet). The result for both the case were obtained by using the simulations in FLUENT at 4 different angle of attack.

It was observed from this work, that using spiroid winglet all the major aerodynamics parameters are reducing. This can be implemented when we concern about the drag alone and this drag is reduced due to the reduction of wing tip vortex. But using spiroid winglet the aerodynamic efficiency (C_L/C_D) is reduced, which is a main disadvantage in aerospace industry. It was concluded on the base of current study that it is not a good practice to reduce the drag by using spiroid winglet because of reduction in aerodynamic efficiency

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