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Vortex Reduction Techinique on Wingtip using Spiroidal Winglet

Gokul Raja E [1] , Hemachandar I [1]
Senthil Kumaran D [1]
[1] UG scholar,
Department of Aeronautical Engineering,
Rajalakshmi Engineering College, Chennai - 602105.

Dr. Muthusamy N [2]
[2] Professor,
Department of Aeronautical Engineering,
Rajalakshmi Engineering College, Chennai - 602105.

***Abstract*: Wingtip vortices at the wingtip strongly influence induced drag for three dimensional wing of an aircraft. It is significant to study the characteristics of wingtip vortices to reduce the induced drag. In order to study the induced drag, the spiroidal winglet is attached to the port and starboard wingtips. A scale model of aircraft wing with conventional winglet and spiroidal winglet was designed and fabricated. The fabricated model was tested at the low speed subsonic wind tunnel (2*2 feet test section) with conventional winglet and spiroidal winglet. The results were obtained by testing the model with conventional winglet, spiroidal winglet and without winglet. The values are tabulated and calculated for lift and drag of wing model with and without winglets. The values are used to calculate the percentage reduction in induced drag. The results indicate the Spiroidal Wnglet is efficient than the conventional winglet.**

Keywords – Wingtip vortices; Induced drag; Spiroidal winglet; Subsonic Wind Tunnel.

I. INTRODUCTION

The aircraft wing experiences induced drag at wingtip. The induced drag is due to formation of wingtip vortices. Richard Whitcomb introduced a device called winglet to reduce wingtip vortices. He used standard winglet to conduct the experiment. There are several types of winglets such as blended, sharklet, dual feather, split scimitar, closed spiroid, standard winglet. Boeing 737 uses blended winglet which saves 4% of total fuel. Airbus 320 uses sharklet which saves 3.5% of total fuel. Boeing 737 uses dual feather which saves 1.5% of total fuel. Boeing 737 uses split scimitar which saves 2% of total fuel. Falcon aircrafts uses closed spiroid which saves 10% of total fuel during cruise. This study deals with the comparison of conventional winglet and spiroidal winglet.

II. EXPERIMENTAL SETUP

Wing lift distribution plays a vital role in the wing design. The lift distribution is directly related to the wing geometry and determines such wing performance characteristics as induced drag, structural weight and stalling characteristics. The geometry of model wing NACA 0012 of span 36.5cm and root chord of 17 cm and tip chord of 6.5 cm. A wing model fabricated with spiroidal winglet of height 5 cm and the angle of attack is 16 degrees. The wing model is placed in the test section of subsonic wind tunnel.

III. PROCEDURE

TEST CONFIGURATIONS

(a)Without winglet:

- For a fixed rpm, the values of lift and drag was calculated with respect to different angle of attack.
- For a fixed angle of attack, the values of lift and drag was calculated with respect to different rpm.

(b)With Conventional winglet:

- For a fixed rpm, the values of lift and drag was calculated with respect to different angle of attack.
- For a fixed angle of attack the values of lift and drag was calculated with respect to different rpm.

(c) With Sproidal winglet:

- For a fixed rpm, the values of lift and drag was calculated with respect to different angle of attack.
- For a fixed angle of attack the values of lift and drag was calculated with respect to different rpm.

Equation used:

$$D = \frac{1}{2} \rho V2SCD$$
$$L = \frac{1}{2} \rho V2SCL$$
$$CDi = CL2 / \pi eAR$$
$$AR = b2 / S$$
$$Di = \frac{1}{2} \rho V2SCDi$$

Terms:

L – Lift
D - Drag
CL - Coefficient of lift
CD - Coefficient of drag
Di - Induced drag
CDi - Coefficient of induced drag
AR - Aspect ratio
b - Wing span
S - Wing area

IV. TABULATION AND GRAPHS

Table 1.1 CL Vs α

Angle of attack	Without winglet	With conventio nal Winglet	With spiroidal winglet
0	0	0	0
4	1.71	1.7	1.71
8	1.92	3.04	3.05
12	2.6	4.75	5.71
16	0.95	3.99	4.08

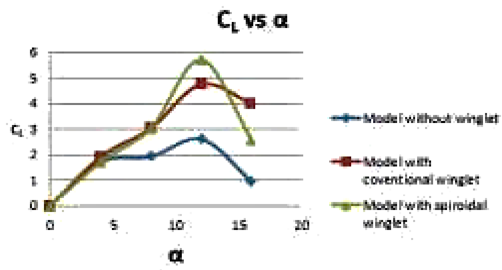

Figure 1.1 CL Vs α

Table 1.1 shows that variation of lift coefficient with respect to various angle of attack without and with conventional winglet and spiroidal winglet of velocity 10 m/s.

Table 1.2 CD vs α

Angle of attack	Without winglet	With conventio nal Winglet	With spiroidal winglet
0	0.68	0.6	0.58
4	1.5	1.44	1.31
8	1.71	1.59	1.52
12	2.4	2.05	1.87
16	3.2	3.12	3

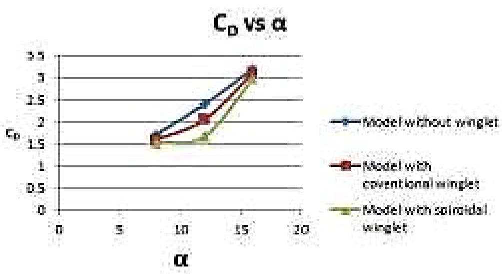

Figure 1.2 CD V α

Table 1.2 shows that variation of drag coefficient with respect to various angle of attack without and with conventional winglet and spiroidal winglet of velocity 10 m/s.

Table 2.1 CL Vs α

Angle of attack	Without winglet	With conventio nal winglet	With spiroidal winglet
0	0	0	0
4	0.71	2.23	2.4
8	1.23	3.18	3.24
12	1.92	4.61	5.23
16	0.99	3.99	4.56

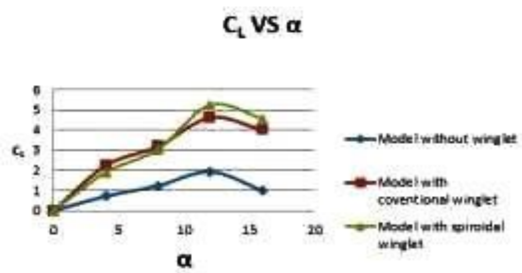

figure 2.1 CL Vs α

Table 2.1 Table 2.1 shows that variation of lift coefficient with respect to various angle of attack without and with conventional winglet and spiroidal winglet of velocity 20 m/s.

Table 2.2 CD Vs α

Angle of attack	Without winglet	With conventio nal winglet	With spiroidal winglet
0	0.43	0.39	0.36
4	0.92	0.91	0.9
8	1	0.93	0.83
12	1.2	0.95	0.89
16	1.46	1.4	1.2

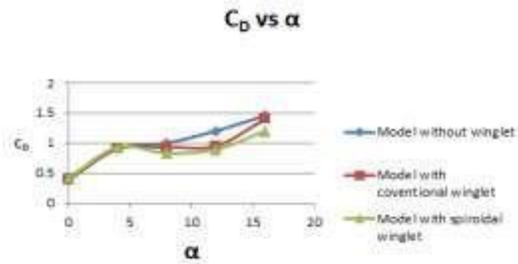

Figure 2.2 CD vs α

Table 2.2 shows that variation of drag coefficient with respect to various angle of attack without and with conventional winglet and spiroidal winglet of velocity 20 m/s.

Table 3.1 CL VS α

Angle of attack	Without winglet	With conventio nal Winglet	With spiroidal winglet
0	0	0	0
4	0.44	1.52	2
8	0.82	2.19	2.56
12	0.9	2.85	2.96
16	0.86	2.55	2.83

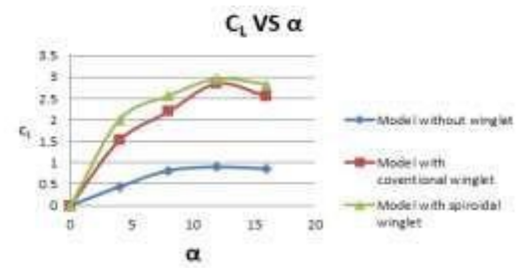

Figure 3.1 CL VS α

Table 3.1 shows that variation of lift coefficient with respect to various angle of attack without and with conventional winglet and spiroidal winglet of velocity 30 m/s.

Table 3.2 CD vs α

Angle of attack	Without winglet	With conventional winglet	With spiroidal winglet
0	0.38	0.34	0.31
4	0.77	0.74	0.71
8	0.85	0.81	0.70
12	1.16	0.9	0.82
16	1.23	1.13	1.1

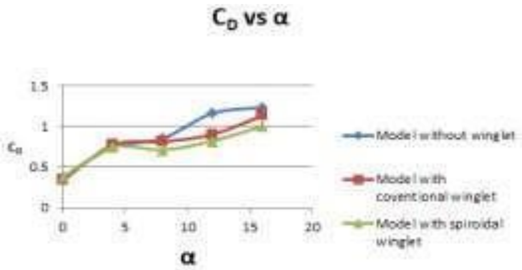

Figure 3.2 C_D vs α

Table 3.2 shows that variation of drag coefficient with respect to various angle of attacks without and with conventional winglet and spiroidal winglet of velocity 30 m/s.

V. RESULTS AND CONCLUSION

The results were compare for without winglet, conventional winglet spiroidal winglet .

velocity	Angle of attack (degree)	% of drag reduction using conventional winglet	% of drag reduction using spiroidal winglet
10 m/s	0	12	14
	4	4	12.6
	8	7	11
	12	14.5	22
	16	2.5	6.2
20 m/s	0	9.3	16
	4	1.1	2.2
	8	7	17
	12	20	25.8
	16	4.1	17
30 m/s	0	11	18.4
	4	3.9	7.8
	8	4.7	17.6
	12	22.4	29.3
	16	8.1	10.6

It is noted that drag formation is more on conventional winglet then the spiroidal winglet, The results indicate the Spiroidal winglet is more efficient than the conventional winglet.

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