ANALYSIS OF AERODYNAMIC PERFORMANCE OF SPIROID WINGLET

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Abstract - *Winglet is a small device attached to the tip of the wing. When winglet is attached increases the lift and reduces the lift-induced drag. During cruise the aircrafts performance is lowered due to vortices at the wingtip and 35–40% of drag will be generated. Induced drag can be reduced and converting them to additional speed, also by reducing fuel usage. We determined the numerical and theoretical analysis of normal wing with and without spiroid winglet. Computational Fluid Dynamic (CFD) analysis is carried out applying boundary conditions. The main objective to compare the aerodynamic performance of the wing with spiroid winglet.*

Key Words: Winglet, Induced drag, Lift, CFD, Normal wing, Spiroid Winglet.

1. INTRODUCTION

The study on Boeing 777 with spiroid winglet and without winglet is studied and compared with different angle of attack. The pressure difference in the wing generates wingtip vortices. By increasing the wing aspect ratio also reduces the drag. Some related papers also prove that spiroid winglet can improve performance of the aircraft.

1.1 Spiroid Winglet

Winglet is a device which is a little projection on the tip of an aircraft wing for reducing drag. So commonly there are many types wing with fence winglets, wing with blended winglets and wing with Raked winglets, wing with semi-circular winglets, and wing with elliptical winglets, spiroid winglets.

Spiroid winglets save airlines lots of fuel by reducing drag. The Spiroid reduces the induced drag generated during cruise. The first aircraft with spiroid winglet is the DASSAULT FALCON 50; it is a three engine super midsized, long –range corporate jet.

2. OBJECTIVES

The main objective of the paper is to learn the spiroid winglets and its applications. The primary aim is to investigate the aerodynamic efficiency of spiroid winglet. The Simulation of spiroid winglet is carried out and also the spiroid winglet is analyzed and the results are compared.

3. METHODOLOGY

Throughout this study, design is developed using CATIA V 5 and the following Computational Fluid Dynamic (CFD) analysis was conducted using ANSYS 18.1 FLUENT. The analysis is carried out under various angle of attack such as 0˚, 4˚, 8˚, 12˚ and 16**.**

4. COMPUTATIONAL FLUID DYNAMIC ANALYSIS

The Computational Fluid Dynamic analysis had been carried out after completing the design in CATIA V 5 for both normal wing with and without spiroid winglet and generated through ANSYS 18.1. The analysis process is solved to determine the grid check, definition boundary conditions, definition simulation flight parameters at various angle of attacks (α = 0˚, 4˚, 8˚, 12˚ and 16˚), flow air velocity 135m/s, operating pressure 19330.4 Pa, temperature 216.650 K, air density 0.310828 kg/m^3 and Mach number 0.457.

4.1 Design Parameters

4.1.1 Geometry model

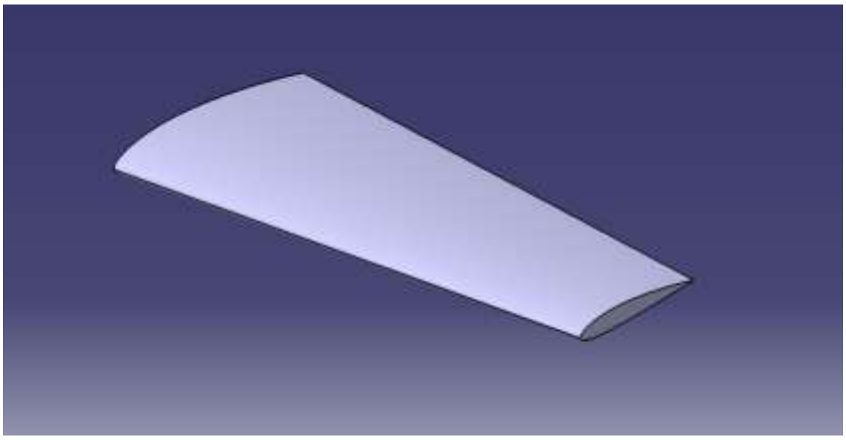

Fig -1: Normal wing without Spiroid winglet

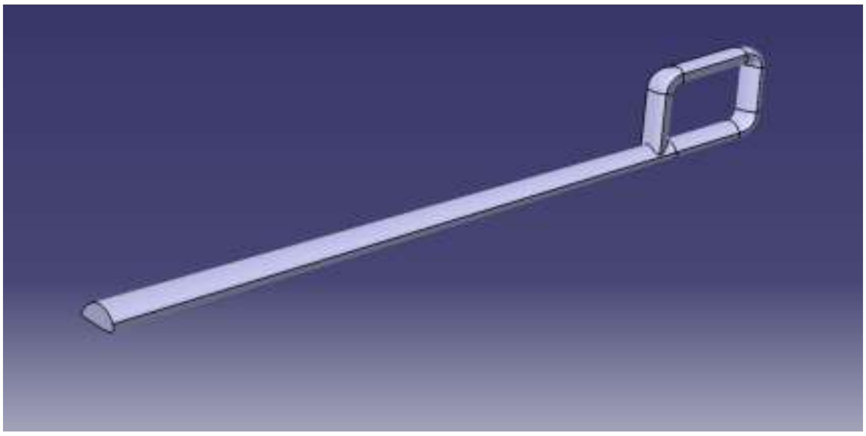

Fig -2: Normal wing with Spiroid winglet

Table -1: Specifications of the Design

SPECIFICATIONS			
S. No	**Parameters**	**Normal Wing without Spiroid Winglet**	**Normal Wing with Spiroid Winglet**
1.	Airfoil	NACA 2412	NACA 2412
2.	Span	25 m	27.8 m
3.	Root chord	5 m	3 m
4.	Tip chord	3 m	3 m
5.	Area	50 m^2	55.6 m^2
6.	Aspect Ratio	6.25	6.95

4.1.2 Meshing

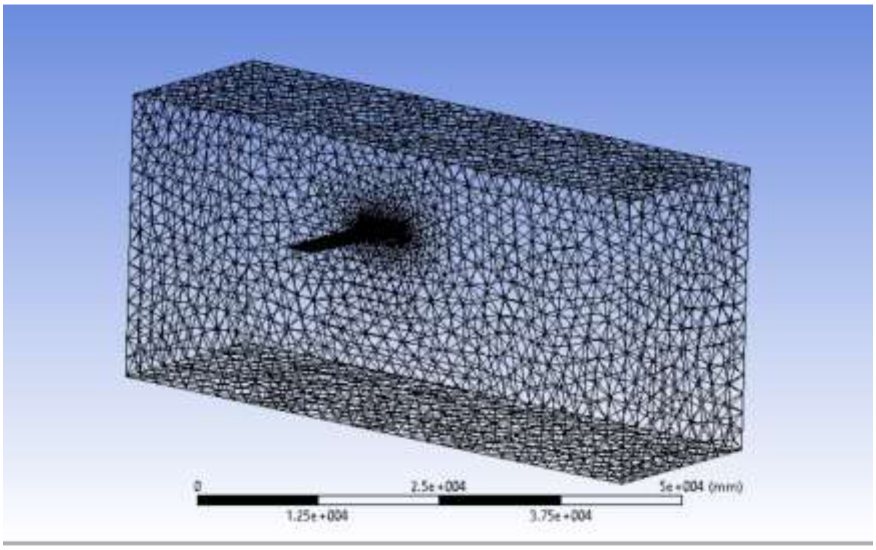

Fig -3: Meshing of Normal wing without Spiroid winglet

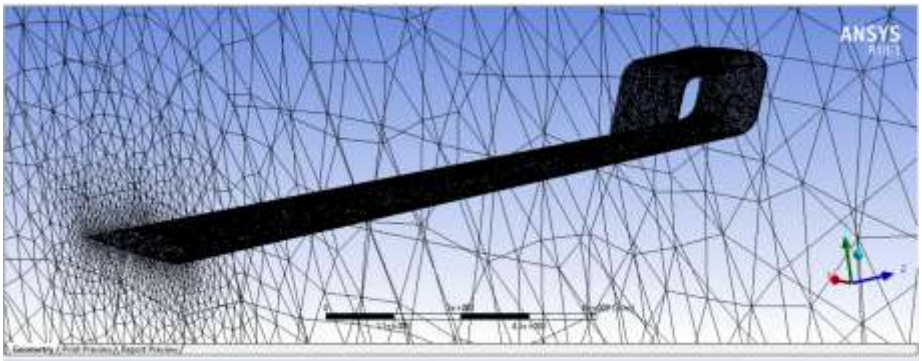

Fig -4: Zoomed mesh view of Normal wing with Spiroid winglet

Table -2: Mesh parameters of the Design

S. No	Parameters	Specifications
1.	Mesh type	Unstructured mesh
2.	Relevance center	Fine
3.	Smoothing	Medium
4.	Inflation	Smooth
5.	Transition ratio	0.272
6.	Maximum layers	5
7.	Minimum size	100.mm
8.	Maximum size	2479.6 mm
9.	Nodes	110561
10.	Elements	596537

5. RESULT & DISCUSSION

Results are obtained in the form of pressure distribution and C_L and C_D charts by using ANSYS 18.1 (FLUENT). The Pressure distribution over the wing with and without spiroid winglet at various angles of attack is shown in the figures below. The color variation over the wing represents the pressure distribution. And also the comparison of C_L and C_D of both the cases are represented in the form chart-1, 2.

5.1 Pressure Distribution of wing without Spiroid winglet at various angle of attack (AOA)

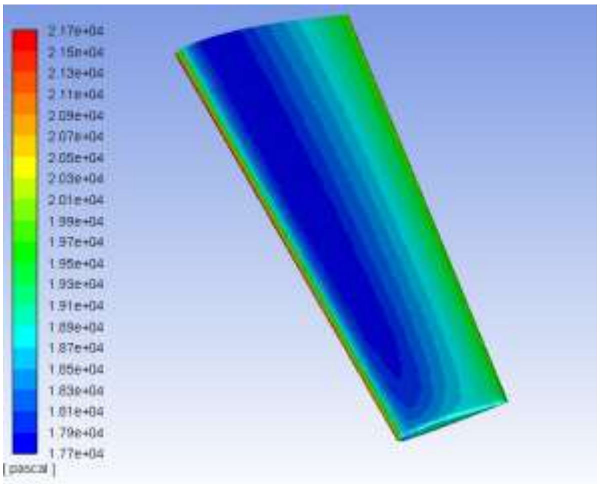

Fig -5: Pressure Contour at 0˚ AOA

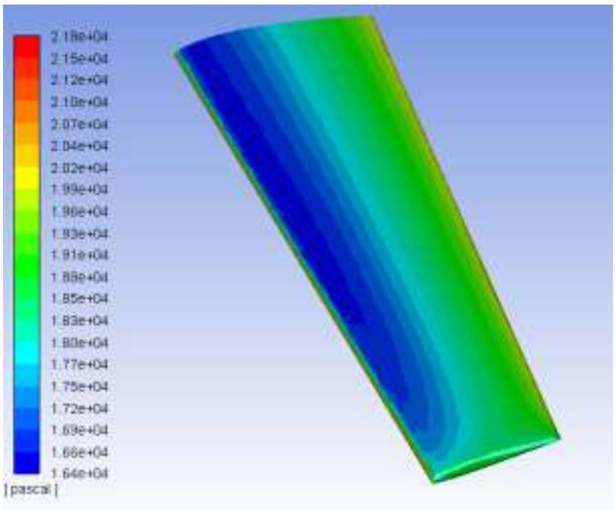

Fig -6: Pressure Contour at 4˚ AOA

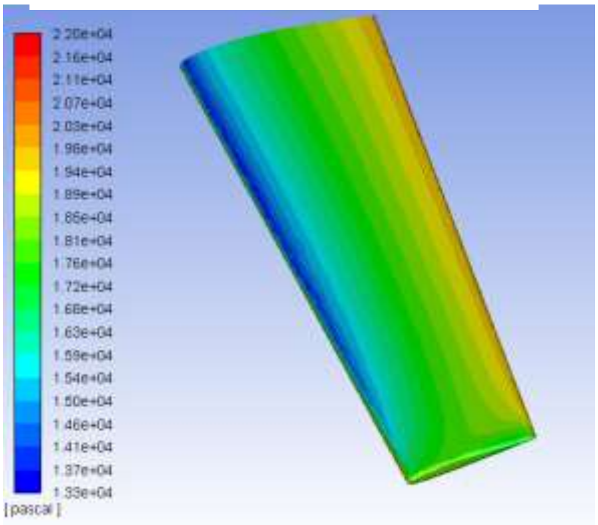

Fig -7: Pressure Contour at 8˚ AOA

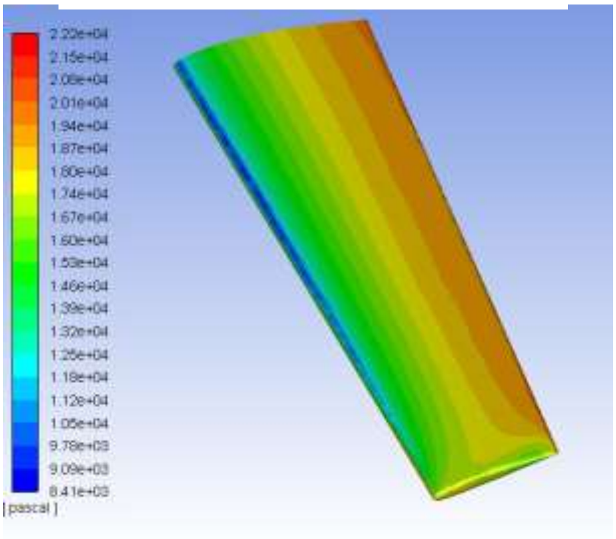

Fig -8: Pressure Contour at 12˚ AOA

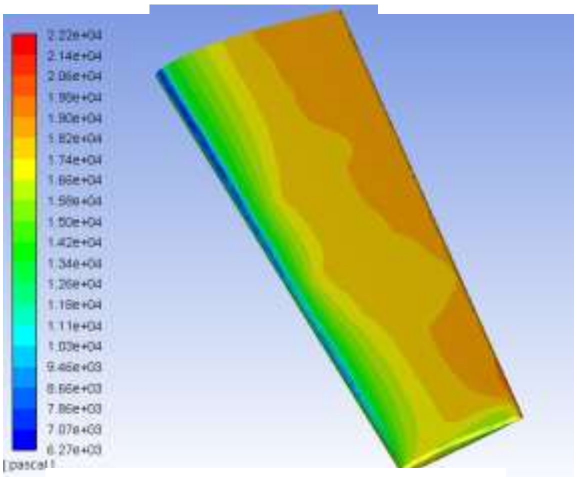

Fig -9: Pressure Contour at 16˚ AOA

5.2 Pressure Distribution of wing with Spiroid winglet at various angle of attack (AOA)

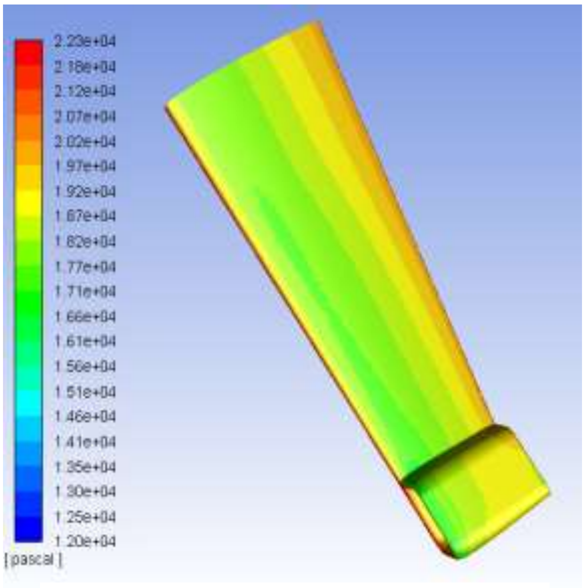

Fig -10: Pressure Contour at 0˚ AOA

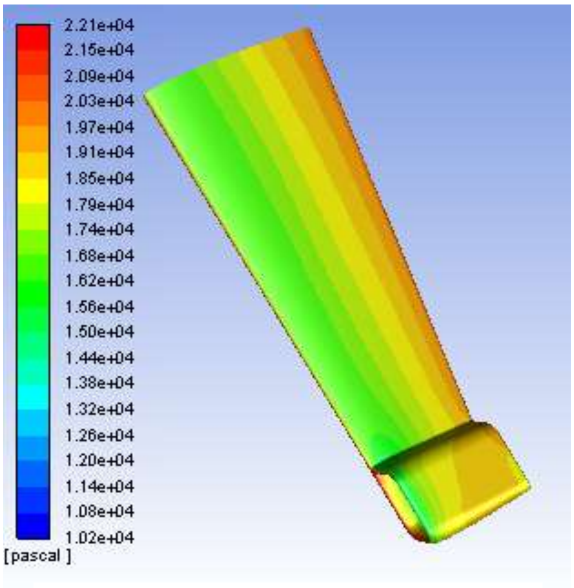

Fig -11: Pressure Contour at 4˚ AOA

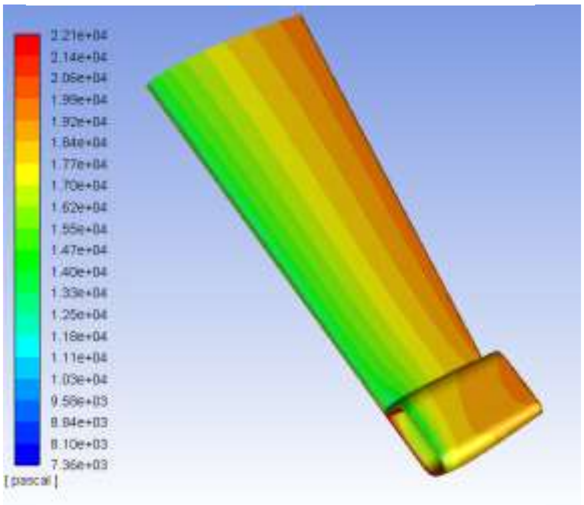

Fig -12: Pressure Contour at 8˚ AOA

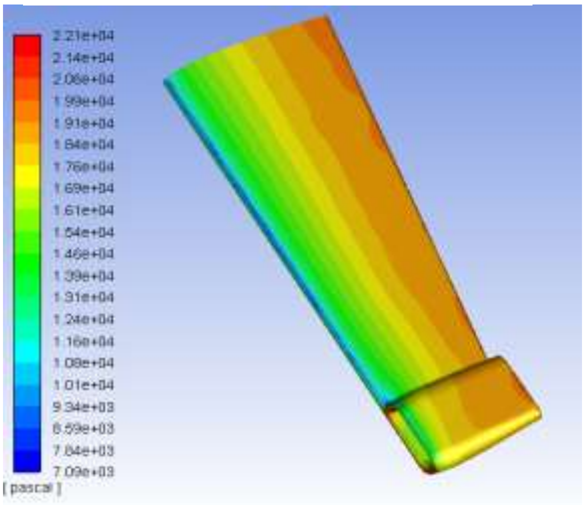

Fig -13: Pressure Contour at 12˚ AOA

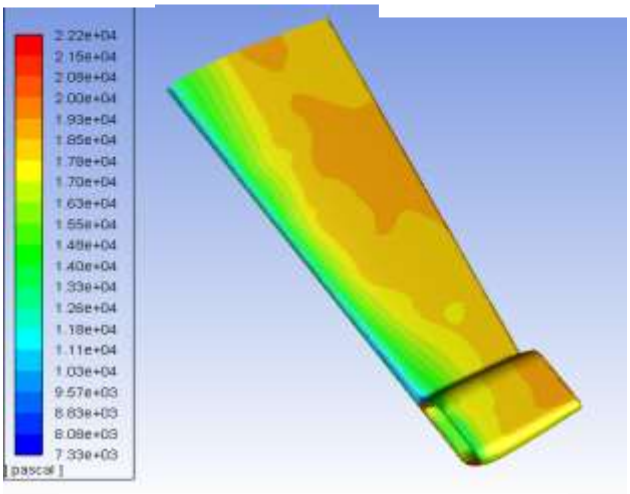

Fig -14: Pressure Contour at 16˚ AOA

5.3 Coefficient of Lift (C_L)

Table- 3: Angle of attack Vs Coefficient of Lift for normal wing with and without spiroid winglet

S. No	Angle of attack (α)	Coefficient of Lift (C_L)	
		Normal wing without spiroid winglet	Normal wing with spiroid winglet
1	0°	0.18910057	0.192637
2	4°	0.52829094	0.590764
3	8°	0.81834011	0.893405
4	12°	1.0083566	1.066686
5	16°	0.9569992	0.893685

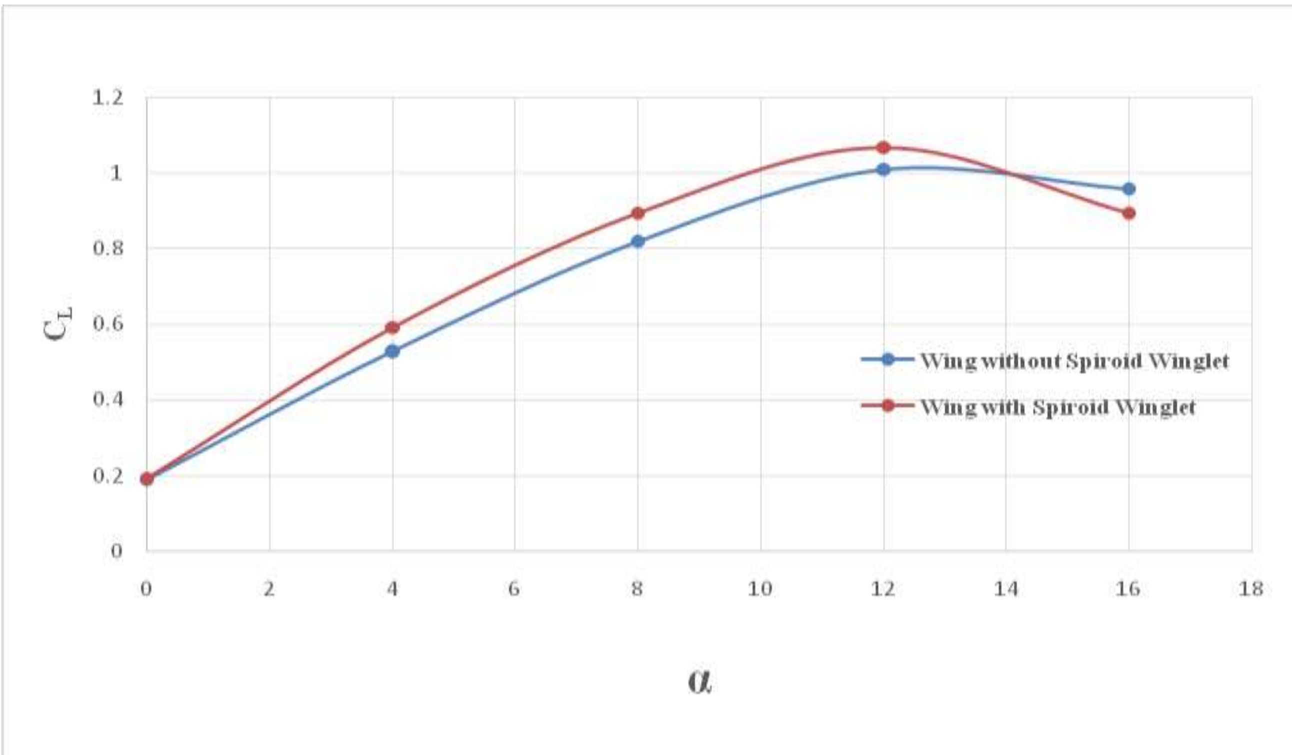

Chart -1: Angle of attack (α) Vs Coefficient of Lift (C_L)

5.4 Coefficient of Drag (C_D)

Table- 4: Angle of attack Vs Coefficient of Drag for normal wing with and without spiroid winglet

S. No	Angle of attack (α)	Coefficient of Drag (C_D)	
		Normal wing without spiroid winglet	Normal wing with spiroid winglet
1	0°	0.011783766	0.011009
2	4°	0.024519724	0.025321
3	8°	0.065959975	0.052736
4	12°	0.11059552	0.09263
5	16°	0.15272595	0.174472

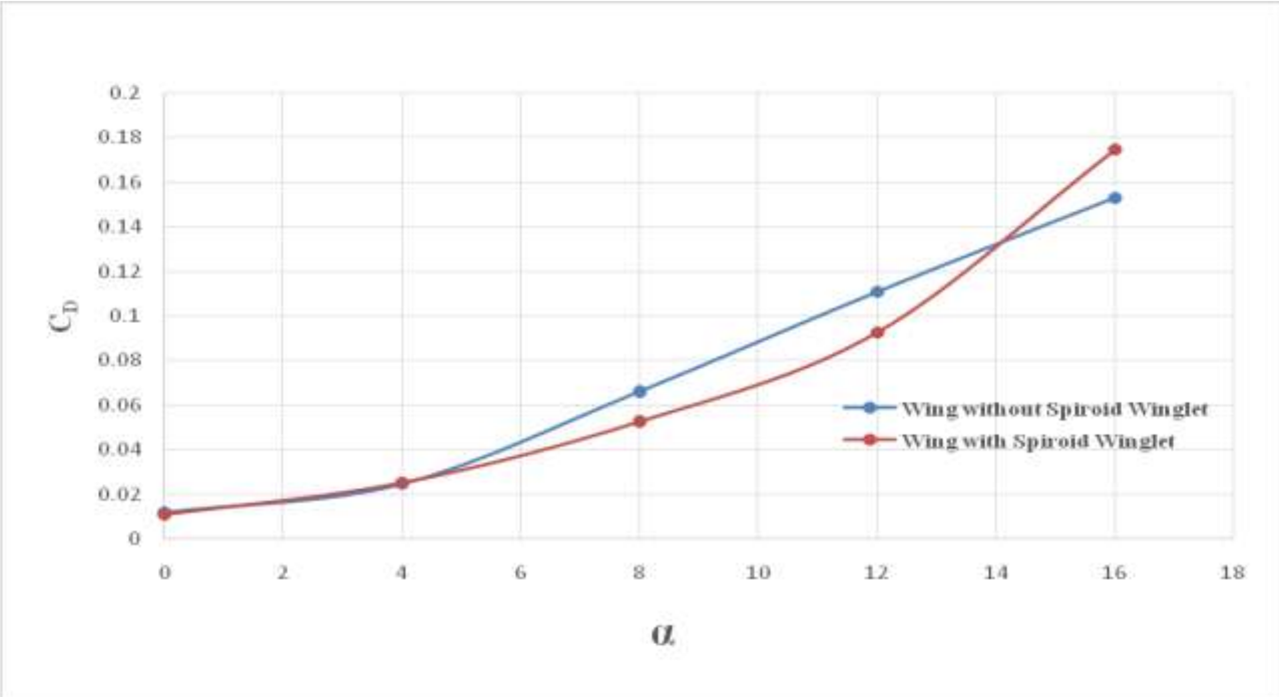

Chart -2: Angle of attack (α) Vs Coefficient of drag (C_D)

6. CONCLUSION

In this paper, the normal wing with and without spiroid winglet is compared to improve the performance of the wing. The comparative study on Boeing 777 with normal wing and other spiroid winglet is compared and studied in detail at various angles of attack (α= 0°, 4°, 8°, 12° and 16°) by software analysis using ANSYS 18.1. From the analysis, comparing the C_L and C_D values it is proven that the performance of the normal wing with spiroid winglet is better than normal wing without spiroid winglet.

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