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COMPUTATIONAL ANALYSIS OF DIFFERENT SHAPES OF DIMPLE ON WINGLETS

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ABSTRACT

The main objective of aircraft aerodynamics is to enhance the aerodynamic characteristics and maneuverability of the aircraft. Winglet design will reduce the fuel consuming by reducing the aircraft drag and makes the aircraft more stable during flight, also it will give the aircraft engine longer life by reducing the load on the engine thrust.
The objective of our project is to design and analyze the flow of Blended winglets model of 60 deg and 75 deg with different types of dimples such as circle and rectangle on the surface of the winglets at various attack angles 0 deg, 10 deg, 14 deg and 18 deg which could potentially allow aircraft to get the best all-around performance
This analysis favors the dimple effect by increasing L/D ratio and thereby providing the maximum aerodynamic efficiency, which provides the enhanced performance for the aircraft.

Keywords: Winglets, Shapes of dimple, Computational analysis and Angle of attacks.

1 . INTRODUCTION

The device attached at the wingtip is called winglet. It is used to lower the induced drag created by wingtip vortices which improves aircraft efficiency. Winglets can be seen as a vertical or angled extension at the wingtip. Winglets increase the effective aspect ratio of wing by defusing the wingtip vortex shed that reduces drag ratio. This cause less fuel consumption.

The dimples on the wing will help to reduce pressure drag and increases the aerodynamic efficiency of wing. Flow separation over normal wing will happen rapidly which forms large turbulent region or wake behind the wing. These causes large pressure drag on the wing. At high angle of attack the wake keeps on increasing as a result it increases the pressure drag. The dimples on the wing works as vortex generator. They create turbulent region in the flow which delays the flow separation over the wing and reduces strength of wake which results in reduction in pressure drag.

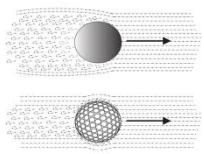


Figure 1.1 – flow separation over smooth and dimpled surface

2.OBSERVATION

2.1DESIGN Two different shapes of dimple which are Circular and square were used and analyzed to get the aerodynamic characteristic of winglet with these dimple shapes. Dimensions of dimple are shown in below table.

Table2.1.1 Dimple dimensions

Sr. No.	Shape	Crossectional Dimensions (in mm)	Depth (in mm)
01.	Circular	4.6	2.3
02.	Square	4.2	2.1

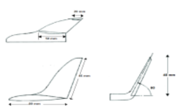


Figure 2.1.1 – Dimensions of winglet

Wing used in the model has airfoil of NACA 0018 series. It is made in tapered shape. The dimensions of wing are as follows:

Table2.1.2Wing dimensions

Sr.No.	**Specification**	**Dimensions (in mm)**
01.	Root chord	110
02.	Tip chord	80
03.	Wing span	315
04.	Taper ratio	1.7

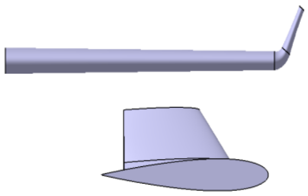


Fig 2.1.2 – without dimple

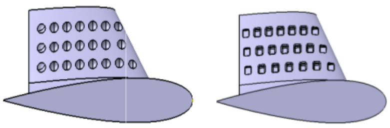


Fig 2.1.3 – inner circular dimple&
Inner rectangular dimple

2.2 MESHING OF THE MODELS

For meshing purpose solid element has been selected. This type of element is used to mesh solid model in ANSYS. These volumes could be created in the ANSYS preprocessor or imported from a CAD system. Hexahedral elements (bricks) can be used to mesh regularly shaped rectangular type volumes, while tetrahedral element can used to mesh any volume three or four node points in a plane and experience bending deformation when loaded by forces transverse to their surfaces. There are different types of solid element used in ANSYS for different condition.

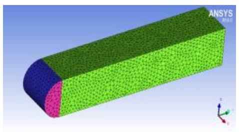


Fig: 2.2.1 Meshed model fluid Domain

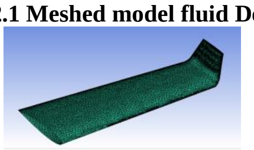


Fig: 2.2.2 Winglet -meshed model

INLET	VELOCITY 20 M/S
OUTLET	PRESSURE OUTLET
SOLVER	VISCOUS K-EPSILON
FLUID DOMAIN	AIR
WALL	Stationery wall, NO SLIP BC

Table 2.2.1: Boundary conditions

2.3RESULT AND DISCUSSION

Simulation is done for the pressure contours and velocity contours of wing with different winglet at two different winglet Cant angles i.e.,60^0 and 75^0. Pressure and velocity contours of wing with different winglets are shown in below Tables

Table 2.3.1- Pressure Contour for 10° AOA

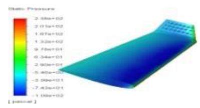
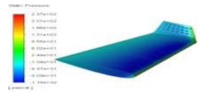
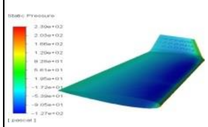
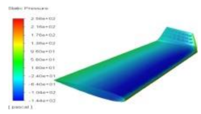
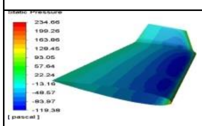
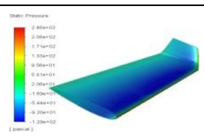
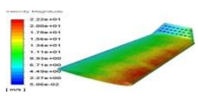
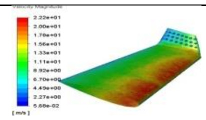
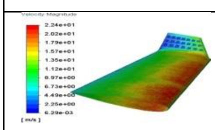
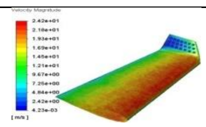
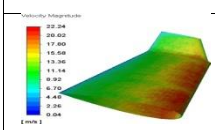
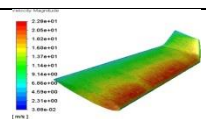
60 Deg	75 Deg
INNER CIRCLE DIMPLE	
	
INNER RECTANGULAR DIMPLE	
	
Without Dimple	
	

Table 2.3.2 - Velocity Contour for 10^0 AOA

60 Deg	75 Deg
INNER CIRCLE DIMPLE	
	
INNER RECTANGULAR DIMPLE	
	
Without Dimple	
	

Velocity values on the wing surface get increased for the winglet having dimples on it. For 60^0Cant angle, velocity value on surface in more for inner rectangular dimple case and for 75^0 Cant angle. For 75^0Cant angle, velocity value get increased more than that of 60^0 Cant angle.

Table 2.3.3- Pressure Contour for 14^0 AOA

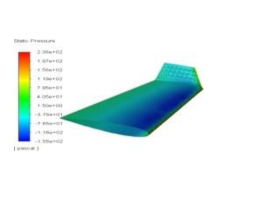
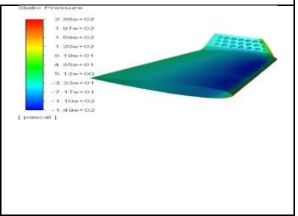
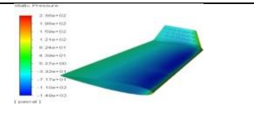
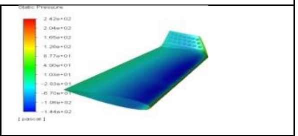
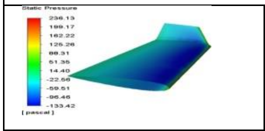
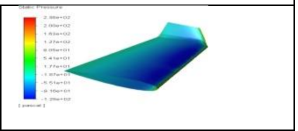
60 Deg	75 Deg
INNER CIRCLE DIMPLE	
	
INNER RECTANGULAR DIMPLE	
	
Without Dimple	
	

Table -2.3.4 Velocity Contour for 14^0 AOA

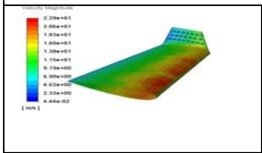
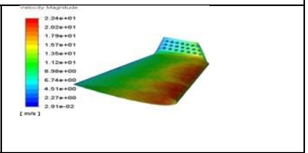
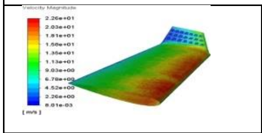
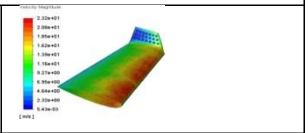
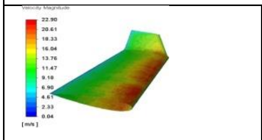
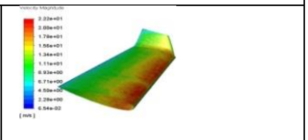
60 Deg	75 Deg
INNER CIRCLE DIMPLE	
	
INNER RECTANGULAR DIMPLE	
	
Without Dimple	
	

Table -2.3.5 Pressure Contour for 18^0 AOA

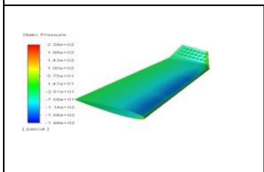
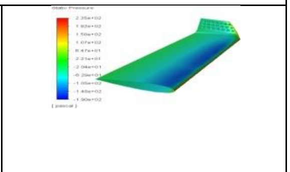
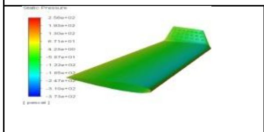
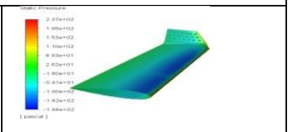
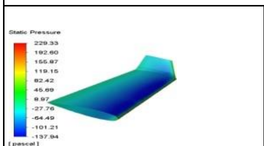
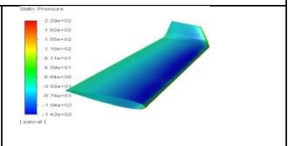
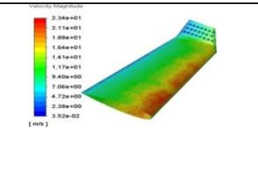
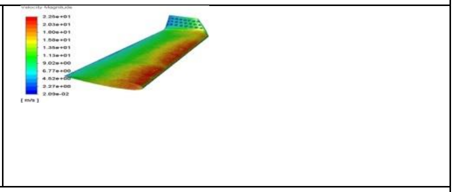
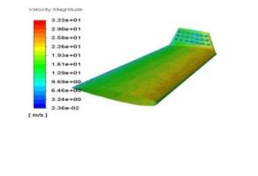
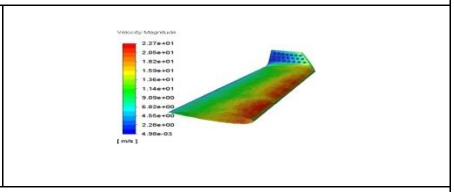
60 Deg	75 Deg
INNER CIRCLE DIMPLE	
	
INNER RECTANGULAR DIMPLE	
	
Without Dimple	
	

Table 2.3.6 Velocity contour for 18^0 AOA

60 Deg	75 Deg
INNER CIRCLE DIMPLE	
	
INNER RECTANGULAR DIMPLE	
	
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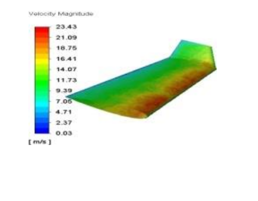
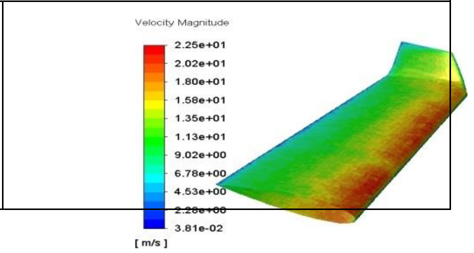
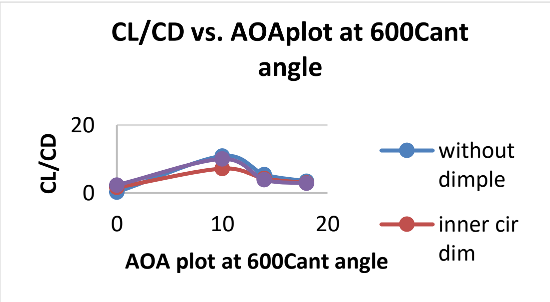
	

2.4 COMPARISON OF C_L/C_D

Plot of C_L/C_D vs. αgives the aerodynamic efficiency of the aircraft. It will helpful to identify the fuel requirement for the particular flight. If the aerodynamic efficiency of the aircraft is more then it will consume less fuel compare to other aircraft having less aerodynamic efficiency. Thus, Plot of C_L/C_D vs. α is very important to know the performance of flight and fuel consumption of aircraft during particular flight on ground testing.

Angle of Attack	without dimple	inner cir dim	inner rec dimple
0	0.270721	1.6317083	2.34886645
10	10.90772	7.2058716	10.0344813
14	5.465626	4.2732432	3.93362565
18	3.43432	2.9457503	2.87212956

Table 2.4.1– C_L/C_D values at 60^0Cant angle



Above figure shows the aerodynamic efficiency of wing at 60^0Cant angle. It can be seen that without dimple case gives the highest value of aerodynamic efficiency and lowest value is given by inner rectangular dimple case. For the case of 75^0Cant angle, highest value of aerodynamic efficiency is given by without dimple case which shown in figure. Least value of aerodynamic efficiency is given by the inner rectangular dimple case. But when compare with the outer rectangular dimple case, aerodynamic efficiency is more than that of all other cases.

Angle of Attack	without dimple	inner cir dim	inner rec dimple
0	1.245270	15.338594	23.861978
10	6.600532	6.285358	5.393529
14	3.334660	3.131303	2.951590
18	2.469884	2.383833	2.307081

Table 2.4.2– C_L/C_D values at 75^0Cant angle

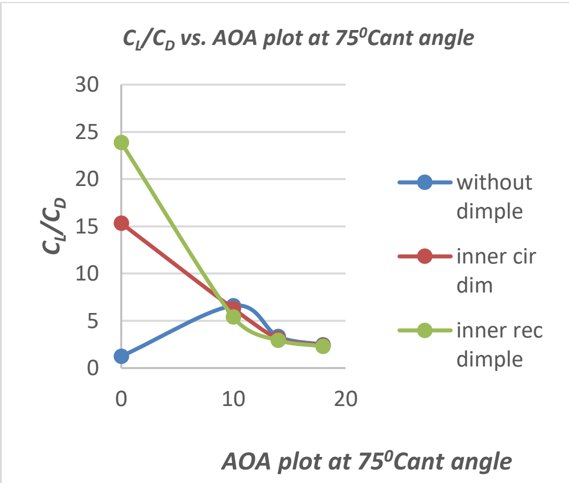


Fig 2.4.2 – C_L/C_D vs. AOA plot at 75^0Cant angle

Above figure shows the aerodynamic efficiency of wing at 60^0Cant angle. It can be seen that without dimple case gives the highest value of aerodynamic efficiency and lowest value is given by inner rectangular dimple case. For the case of 75^0Cant angle, highest value of aerodynamic efficiency is given by without dimple case which shown in figure. Least value of aerodynamic efficiency is given by the inner rectangular dimple case. But when compare with the outer rectangular dimple case, aerodynamic efficiency is more than that of all other case.

3.CONCLUSION

After the Analysing the result

- Lift coefficient for is maximum at 18^0 AOA for the case of inner rectangular dimple case for both cases.
- Drag coefficient is less for without dimple case for both Cant angles of winglet for both cases.
- The overall aerodynamic efficiency of wing with inner rectangular dimple winglet is more than that of wing with other type of winglets.

Finally, We Conclude that Inner Rectangular Dimple Model is best among other models

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