

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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## Fabrication and Experimental Analysis of Aircraft Winglet

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**ABSTRACT:** Winglet is one of the important techniques to reduce the drag in the commercial airplane. This paper is main involved to increase lift and minimize the drag analysis at various angle of attack respectively clean wing and 45°, 72° winglet. Experimental testing has been taken in wind tunnel machine for winglet 45°, 72° & clean wing. Lift, drag & moment has been calculated by theoretical analysis. From those parameters, co-efficient of drag when been calculated. By comparing the co-efficient of drag with different angle of attack, the angle of winglet with minimum  $C_D$  has been found & thrust specific fuel consumption for that value has been determined.

**KEYWORDS:** CLEAN WINGLET & WINGLET 45°, 72° .

### I. INTRODUCTION

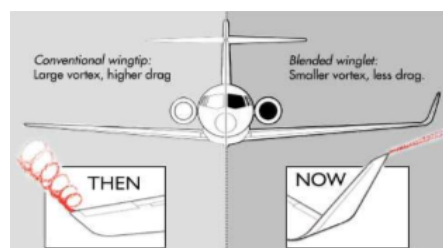


Fig 1.1

### II. LITERATURE SURVEY

**Cosin. R., Catalano, “ AERODYNAMIC ANALYSIS OF THE USE OF MULTI-WINGLETS IN LIGHT AIRCRAFTS”.** The major objective of this work is to analysis the aerodynamic characteristics of multi-winglets applied to light aircrafts. This wing tip device has demonstrated a potential of improving the aerodynamic efficiency of aircrafts by the reduction on the induced drag. The data discussed were results of experimental investigations for a wing-body half model at  $Re = 4 \times 10^5$  with six different multi-winglet configurations plus the base line. It was achieved up to 7.3% of increase on maximum aerodynamic efficiency and even greater values for others medium to high lift coefficient regimes' performance analysis was also conducted revealing a potential increase of 12% on maximum climb ratio

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**AltabHossain,AtaurRahman,A.K.M.P.Iqbal,M.Ariffin, and M. Mazian, “DRAG ANALYSIS OF AN AIRCRAFT WING MODEL WITH AND WITHOUT BIRD FEATHER LIKE WINGLET”**.This work describes the aerodynamic characteristic for aircraft wing model with and without bird feather like winglet. The aerofoil used to construct the whole structure is Rectangular wing and this aerofoil has been used to compare the result with previous research using winglet. The model of the rectangular wing with bird feather like winglet has been fabricated using polystyrene before design using

fabricated in wood. The experimental analysis for the aerodynamic characteristic for rectangular wing without winglet, wing with horizontal winglet and wing with 60 degree inclination winglet for Reynolds number  $1.66 \times 10^5$ ,  $2.08 \times 10^5$  and  $2.50 \times 10^5$  have been carried out in open loop low speed wind tunnel at the Aerodynamics laboratory in University Putra Malaysia. The experimental result shows 25-30 % reduction in drag coefficient and 10-20 % increase in lift coefficient by using bird feather like winglet for angle of attack of 8 degree.

**Prithvi Raj Arora1, “DRAG REDUCTION IN AIRCRAFTMODELUSINGELLIPTICALWINGLET”**.Aerodynamic characteristics for the aircraft model with NACA (National Advisory Committee for Aeronautics) wing No. 65-3-218 have been studied using subsonic wind tunnel of 1000 mm x 1000 mm rectangular test section and 2500 mm long of Aerodynamics Laboratory Faculty of Engineering (University Putra Malaysia). Six components wind tunnel balance is used for measuring lift, drag and pitching moment. Tests are conducted on the aircraft model with and without winglet of two configurations at Reynolds numbers  $1.7 \times 10^5$ ,  $2.1 \times 10^5$ , and  $2.5 \times 10^5$ . Lift curve slope increases more with the addition of the elliptical winglet and at the same time the drag decreases more for the aircraft model with elliptical shaped winglet giving an edge over the aircraft model without winglet as far as Lift/Drag ratio for the elliptical winglet is considered. Elliptical winglet of configuration 2 (Winglet inclination 600) has, overall, the best performance, giving about 6% increase in lift curve slope as compared to without winglet and it is giving the best lift/drag ratio.

## III. EXPERIMENTAL DETAILS

**WINGLET MODEL:** Our project is to compare the clean wing and 45°, 55°&65° winglet. The NACA 0012 is the selected series. **FABRICATION:** The model fabricate in wood. The scale is subsonic wind tunnel testing table value. **WINGLET SCALE:** All dimensions are in centimeter.

### CLEAN WINGLET SCALE VALUE

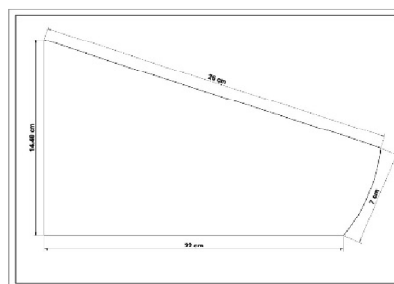


Fig 1.2

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Vol. 8, Issue 3, March 2019

WINGLET 45° SCALE VALUE

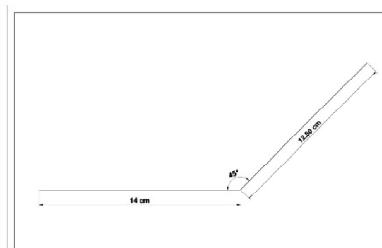


Fig 1.3

WINGLET 72° SCALE VALUE  
WINGLET45°, 72°

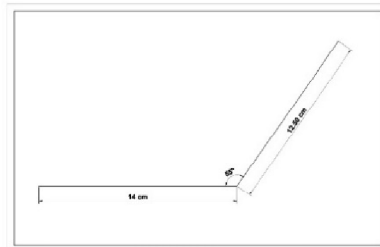


Fig 1.6, 1.7 & 1.8

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## DESIGN CALCULATION

### X-LIFT, Y-DRAG, Z-MOMENT & $\alpha$ -ANGLE OF ATTACK

**EXPERIMENTAL ANALYSIS:** The lift and drag value of wing with winglet at different angle is determined by using the value of coefficient of lift and drag values.

## DETERMINATION OF LIFT, DRAG & MOMENT CALCULATION

The general equation of lift, drag & moment are

$$L = (1/2) \times \rho \times V^2 \times S \times C_L$$

$$D = (1/2) \times \rho \times V^2 \times S \times C_D$$

$$M = (1/2) \times \rho \times V^2 \times S \times C_M \times \bar{C}$$

S-wing area

$\rho$ -density

V -velocity

$C_L$ -coefficient of lift

$C_D$ -coefficient of drag

$C_M$ -coefficient of moment

$\bar{C}$  - Mean Chord of Wing

## CLEAN WING CALCULATION

$$V = 30 \text{ m/s}$$

$$\rho = 1.1653 \text{ kg/m}^3$$

$$S = \text{Wing Area}$$

$$= (\text{Chord} \times \text{Span})$$

$$= 14.4 \times 24 = 345.6 \text{ cm}^2 = 0.0345 \text{ m}^2$$

$$\bar{C} = 0.13 \text{ m}$$

## WINGLET CALCULATION

$$V = 30 \text{ m/s}$$

$$\rho = 1.1653 \text{ kg/m}^3$$

$$S = \text{Wing Area}$$

$$= (\text{Chord} \times \text{Span})$$

$$= 14.4 \times 26$$

$$= 374.4 \text{ cm}^2 = 0.0374 \text{ m}^2$$

$$\bar{C} = 0.13 \text{ m}$$

## DETERMINATION OF COEFFICIENT OF LIFT, DRAG AND MOMENT

$C_L$  at  $0^\circ$ ,

$$L = X \times g$$

$$= 0.57 \times 9.81$$

$$= 5.59$$

$$L = (1/2) \times \rho \times V^2 \times S \times C_L$$

$$= (1/2) \times 1.1653 \times (30^2) \times 0.0345 \times C_L$$

$$C_L = 0.30$$

$C_D$  at  $0^\circ$ ,

$$D = Y \times g$$

$$= 2.64$$

$$D = (1/2) \times \rho \times V^2 \times S \times C_D$$

$$= (1/2) \times 1.1653 \times (30^2) \times 0.0345 \times C_D$$

$$C_D = 0.14$$

$C_M$  at  $0^\circ$ ,

$$M = Z \times g$$

$$= 0.31 \times 9.81$$

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$$M = (1/2) \times \rho \times V^2 \times S \times C_M \times \bar{C}$$

$$= (1/2) \times 1.1653 \times (30^2) \times 0.0345 \times C_M \times 0.13$$

$$C_M = 1.29$$

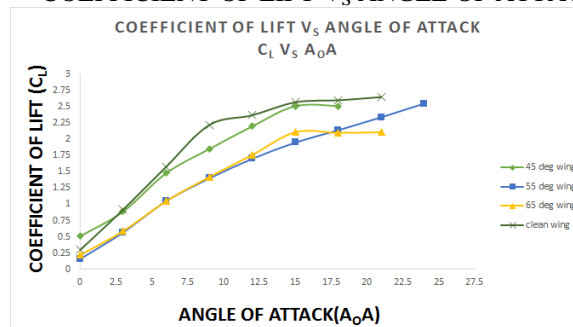
The similar calculation is used for different angle of attack like 3°, 6°, 9°, 12°, 15°, 18°, 21° & 24°.

## IV. RESULT AND DISCUSSION

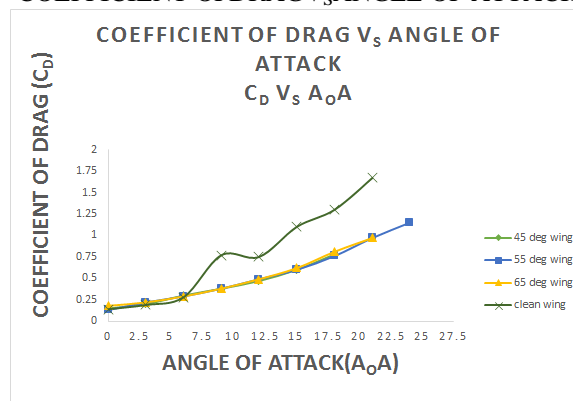
From the calculation we get winglet 72° is the best angle to reduce drag among the four angles. (Only 0°, 3°, 6° & 9° is taken.)

### GRAPH:

COEFFICIENT OF LIFT  $V_s$  ANGLE OF ATTACK



COEFFICIENT OF DRAG  $V_s$  ANGLE OF ATTACK



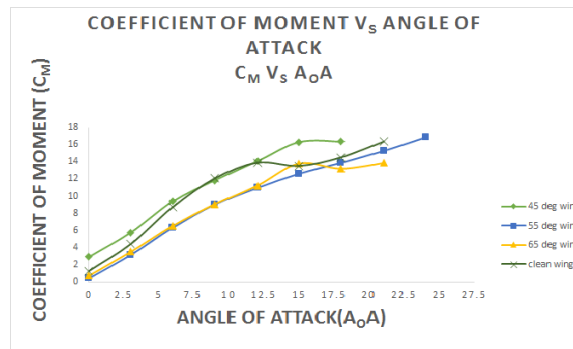
COEFFICIENT OF MOMENT  $V_s$  ANGLE OF ATTACK

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From the calculation we get winglet  $72^\circ$  is the best angle to reduce drag among the four angles. (Only  $0^\circ$ ,  $3^\circ$ ,  $6^\circ$  &  $9^\circ$  is taken.)

## THRUST SPECIFIC FUEL CONSUMPTION (TSFC)

TSFC is determined from the values of  $72^\circ$  winglet.

$$TSFC = \dot{m}_f / F$$

$\dot{m}_f$  – fuel mass flow rate-----kg/s

F – net thrust-----N (or) kgm/s<sup>2</sup>

Thrust (or) drag  $\times$  gravity

$$= 0.31 \times 9.81$$

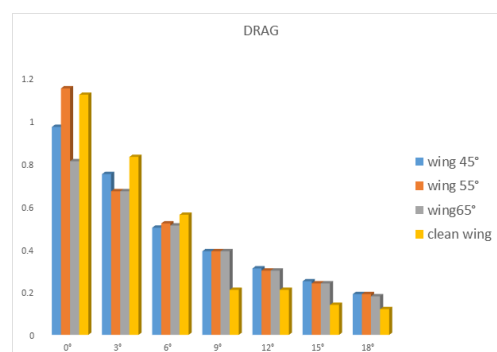
$$= 3.04 \text{ N}$$

$\dot{m}_f = 4$  liter/second for aircraft fuel consumption

$$= 2.957 \text{ kg/s}$$

$$TSFC = 2.957 \div 3.04$$

$$= 0.97 \text{ s/m}$$



From the graph we get winglet  $55^\circ$  is the best angle to reduce TSFC.

The best angle of attack is  $3^\circ$ .

## V. CONCLUSION

In our project we have analysed clean wing and winglet of  $45^\circ$ ,  $55^\circ$ ,  $65^\circ$ .

We have analysed the aerodynamic force & moment with different angle.

We have taken experimental reading for subsonic wind tunnel for the winglet different angle of attack like  $45^\circ$ ,  $55^\circ$ ,  $65^\circ$  & clean wing.

From the reading we calculated the lift, drag and moment.

From the calculation we selected 1 winglet  $72^\circ$  is the best angle to reduce drag among the four winglet. (Only  $0^\circ$ ,  $3^\circ$ ,  $6^\circ$  &  $9^\circ$  angle of attack is taken.)



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Vol. 8, Issue 3, March 2019

From the calculation we found winglet  $72^\circ$  is the best angle with less TSFC, and also the best angle of attack is  $3^\circ$ .

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- J. D. Anderson