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# Design and Angle of Contact (AoA) analysis of Remote Control (RC) Aircraft

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**ABSTRACT-** In this paper, the design of a prototype of Remote Control (RC) aircraft is discussed. It is important and interesting to learn about the workings, terminology, factors affecting to flight, construction, application, and advantage of the aircraft. Also, studied about the designing aeronautics formula rules and analytical equations of aircraft lift force and drag force of a RC airplane for AOA analysis. In addition, aerodynamic performance is carried out on the airfoil type wing to determine the drag and lift forces at maximum speed.

**KEYWORDS-** RC Airplane, Design, 3D Modeling, AOA, Drag Force, Lift Force, Analytical formulas

## I. INTRODUCTION

Aerodynamic study is a crucial phase in the design process for aircraft. The results of the aerodynamic analysis are used to calculate the lift force and drag force. Lift force must be maximized and drag force must be minimized to increase fuel efficiency. S.S.Hedges et.al [1] studied about comparison between experimental and analytical on the flow around a landing gear truck wheels. Ryan.B et.al [2] studied about 3D modeled of airplane about static analysis and aerodynamic loads on conic lofting wing design under various parameters. Harish M et al. [3] investigated on the Lift to Drag (L/D) ratios to identify the aerodynamic analysis on a wing surface perpendicular to the direction of motion by traveling in air. C.Rakesh et.al [4] studied about design of duct fan and static thrust loads on the pipe to keep to tapping holes. In addition that measures the static pressure and thrust force of the ductfan. M.H.Doğru et. al. [5] studied about self-weight of landing gear, static, modal and shock loads on a RBE3 connection at the axle end spreading to wheel base. S.K.Murthy et. al. [6] reveals the effect of static and thrust analysis on a ducted fan which is connected inside the ground effect region. B.Sweeten et.al [7] investigated on turbulence and velocity distribution on various tip shapes by Using CFD Analysis. In addition, the effect of pressure and velocity distribution on the various tips geometries.

## II. DESIGN OF RC AIR PLANE

### A. *Design of wing*

In the RC Flight, the lift force is dependent on the density of the air (ρ), the airspeed (V), the wing's Lift Coefficient and the wing's area.
According to the formula [8]:
Lift Force = 0.5 * ρ * $V^2$ * Wing's Lift Coefficient * Wing's Area
In aircraft design assume that the weight of all parts of aircraft will be less than 2.9 kg. So the lift weight should be capable near to 3 kg.
Also consider
Air density = 0.98
Coefficient of lift = 1
Velocity = 22.22 m/s
Area = 0.23 $m^2$
The relationship between Wing's Lift Coefficient, the wing's aspect ratio (AR) , Reynolds Number (Re) and angle of attack (α) before reaching the stall angle.

$$L = 0.5 \times Cl \times \rho \times V^2 \times A$$
$= 0.5 \times 1 \times 0.98 \times 22.22^2 \times 0.23$
$= 55.64\ N$
$= 5.6\ Kg$

However, the wing's generation of lift also produces induced drag, which along with parasitic drag forces are that opposes the aircraft's motion through the air. Induced drag is also dependent on the density of the air (ρ), the air speed (V), the wing's drag coefficient and the wing's area.
According to the formula [9]:
Drag force = 0.5 * ρ * $V^2$ * Wing's drag coefficient * Wing's area

$D = 0.5 \times Cd \times \rho \times V^2 \times A$
$= 0.5 \times 0.5 \times 0.98 \times 22.22^2 \times 0.23$
$= 27.82\ N$
$= 2.7\ Kg$

$Max.$ Lift capacity= Lift force − Drag force
$= 5.6 - 2.7$
$= 2.9\ Kg$

Wings area = Lift force/0.5 ∗ρ ∗ V2 ∗ Wing′s lift coefficient

$55.64/0.5 \times 1 \times 22.22^2 \times 0.98$

$= 0.23\, m^2$

A=2300cm$^2$

Assume that, $Aspect\ rato\ (AR) = span\ lenth/chord\ lenth$

$Wing\ area = Span\ length \times chord\ length$

$2300 = S \times C$

$2300 = 4.347\ C \times C$

$$C = \sqrt{2300/4.347}$$

C = 23cm

Aspect ratio =Span length/Chord Length

4.347 = S/23

S=100 cm

Aileron length ($A_l$) = 1/8 × Chord

= 1/8 × 23

= 2.875 cm

$A_l \cong 3.00\ cm$

$Wing\ thickness$ = 10. 50 % $of\ chord$

= 10.50 ×23/100

t=2.4cm

$Distance\ of\ leading\ edge\ to\ max.\ thickness = 35\ \%\ of\ chord$

= 35×23/100

=8.05 cm

### B. Design of Fuselage

The design of fuselage is obtained from the relationship between aircraft wing span length and various standard thumb rules are used dimension of aircraft fuselage.

$Fuselage\ length\ (l)$ = 96. 7 % $of\ wing's\ span\ length$

= 96.7× 100/100

l =96.7 cm

$Fuselage\ height\ (h)$ = 12. 40 % $of\ fuselage's\ length$

= 12.40× 100/96.7 h = 12cm

$Fuselage\ width$ (w) = $width\ of\ mounting$

w= 6cm

### C. Design of stabilizer

The design of stabilizer is carried out through the standard dimensions of aircraft wing. Generally for trainer model some standard thumb rules are used which is given as formula for various dimension of aircraft stabilizer.

$Stabilizer\ area$ = 22. 5 % $of\ wing's\ area$

=22.5×2300/100

a=515.2cm$^2$

Assume that, $Aspect\ rato\ (AR)$ = $Span\ lenth/Chord\ lenth$

= 2.0125

$Stab\ area = Span\ length \times chord\ length$

515.2 = $S \times C$

515.2 = 2.0125 $C \times C$

$$\sqrt{515.2/2.0125} = C$$

C=16cm

$Aspect\ ratio\ (AR)$ = $span\ length/chord\ length$

2.0125 = $S/16$

S=32.2cm

$Elevator\ area = 18.75\ \%\ of\ 's\ area$

=18.75×515.2/100

a= 96.6cm$^2$

$Elevator\ length$ = Elevator Area/Span Length

= 96.6/32.2

$E_l$ = 3cm

### D. Design of Fin

The design of Fin is obtained from the various dimension of aircraft stabilizer. Generally for trainer model some standard thumb rules are used which is given as formula for various dimension of aircraft fin.

$Fin\ area$ = 46. 5 % $of\ Stab's\ area$

= 46.5×515.2/100

a=240cm$^2$

Assume that, $Aspect\ rato\ (AR)$ = $Span\ lenth/chord\ lenth$

= 0.937

$Fin\ area = Span\ length \times chord\ length$

240 = $S \times C$

240 = 0.937 $C \times C$

$$\sqrt{240/0.937} = C$$

$C_l$= 16cm

$Aspect\ ratio\ (AR)$ =$span\ length/chord\ length$

0.937 =$S/16$

S=15cm

Fin is the 65’ trapezoidal shape so the lower chord length and upper chord length are not same. Therefore now we will find the upper chord length by following formula.

$Upper\ fin\ chord\ length$ = Lower $chord - Span\ length/$ tan 65

= 16 − 15/tan 65

$C_u$ = 9cm

$Rudder\ area$ = 25 % $of\ Fin's\ area$

= 25 ×240/100

a = 60cm$^2$

$Rudder\ length$ =$Rudder\ area/Fin\ Span\ length$

= 60/15

$R_l$ = 3cm

Rudder is the 20’ trapezoidal shape so the Fin span length and rudder span length are not same. the rudder span length using the below formulae.

$Rudder\ span\ length$ = Fin $span$ − (tan 20 × $Rudder\ length$)

= 15 − (tan 20 × 4)

= 13.5cm

### E. Design of Landing gear

The relationship between landing gear wheel diameters of the aircraft, thickness of wheel, height of the link, and distance b/w two wheels as shown in below the formulas

$Landng\ gear\ wheel\ dameter$ d = 4cm

Thickness of wheel t = 2cm

$Heght$ of $link$, h= 14.5cm

$Dstance\ between$ two wheels l =12cm

## III. MODELING AND AOA ANALYSIS OF RC AIR CRAFT

From Figure 1, 3D solid model of Airplane designed in Solid works. After modeled to determine the performance analysis based on the, lift force and drag force values are determined. Lift force must be maximized and drag force must be minimized to increase fuel efficiency [5].

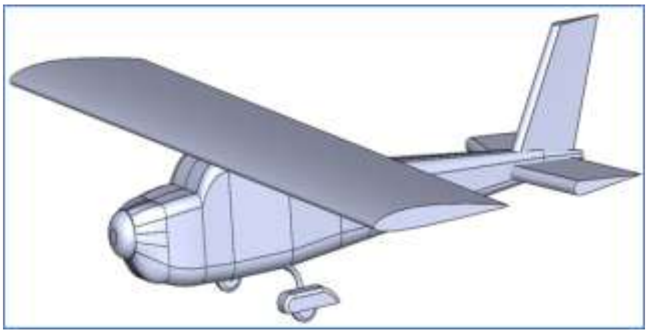

Figure 1: Solid Model of Airplane

### A. *Stall and Spin*

From Figure 2 speed chosen for landing is 1.3 times the stall speed. Stall is an undesirable phenomenon in which the aircraft wi
Attack (AoA).

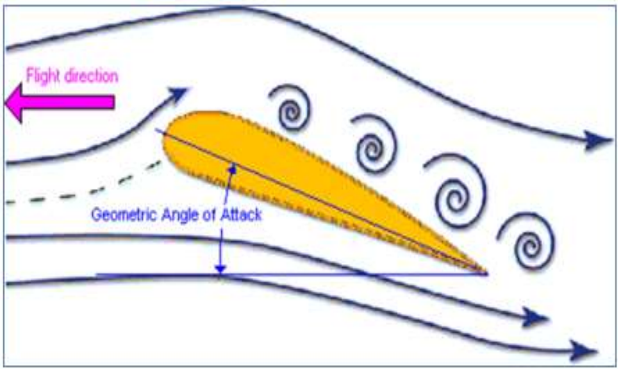


Figure 2: Stall and AOA

In RC Flight, the lift force is proportional to the density of the air (ρ), the square of the air speed (V), the type of airfoil and to the wing's area

According to the formula [10]:

Lift force = 0.5 * ρ * $V^2$ * wing's lift coefficient * wing area

Since lift coefficient is proportional to the angle of attack, the lower the air speed the higher the angle of attack has to be in order to produce the same lift as shown in Fig3.3.

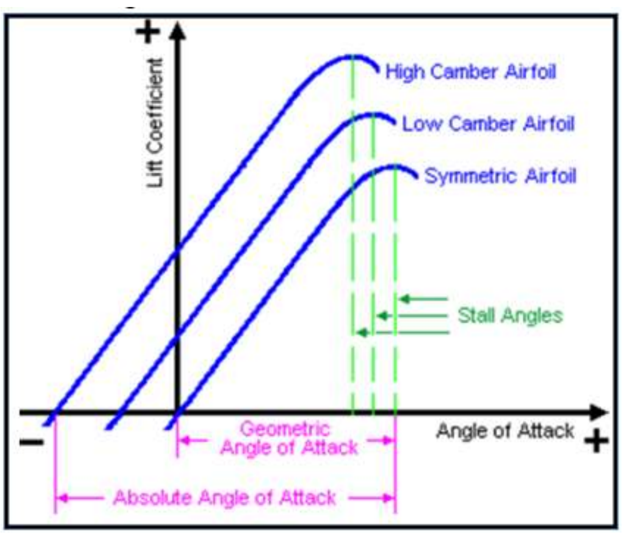


Figure 3: Lift coefficient v/s angle of attack

Table 1: Lift and Drag Force Results

| | Lift Force (N) | Drag Force (N) |
|---|---|---|
| $0^o$ AoA | 20.5 | 12.8 |
| $5^o$ AoA | 46.7 | 14.7 |
| $10^o$ AoA | 75.6 | 14.2 |
| $15^o$ AoA | 98.4 | 14.8 |
| $20^o$ AoA | 116.8 | 14.9 |

When the results which are given in Table 1 are compared, drag force and lift force values are increased due to AoA increment.

## IV. CONCLUSION

The design of a prototype of RC aircraft is a very important and interesting project in the mechanical field. The following conclusions are drawn:

- In this paper, we design an RC Airplane to consider the working, terminology, factors affecting flight, construction, application, and advantage of the aircraft.
- studied the design of aircraft. Check out the aeronautics formulas, rules, and equations as well.
- studied about the errors that came from the preparation of the model. Then, learn how to fly the aircraft with a remote control.
- studied further than making appropriate changes in the design to make sufficient aircraft. The change in the model shape increases the speed of the aircraft, and the change in the thrust system means we arrange the gasoline engine instead of a motor, which increases the lift power and makes it a 3D aerobic plane.
- A RC airplane's lift and drag forces are calculated using an airfoil as the wing.
- Flow trajectories of velocity and pressure on an airplane are given at different AoA values (00, 50, 100, 150, and 200). After this study, it is shown that both drag force and lift force values are increased due to AoA.

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