DESIGN AND FABRICATION OF RC PLANE WITH FLEXIBLE WINGS

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ABSTRACT

Flexible aircraft wings instantaneously and minutely adjust its control surfaces during flight. By designing and installing these wings we will attain a result closer to optimal performance by adjusting the curvature of the wing's trailing edges and increases an airplane's lift-to-drag ratio, which is a measure of aerodynamic efficiency, in response to variations in speed, altitude, air temperature, and other flight conditions. Flexible wing smoothly adjusts its camber to minimize drag during flight. The main objective of this project is to replace traditional flaps with an aero elastic flexible wing in a RC plane. The advantages of using a flexible wing is that, it leads to quieter landings, less turbulent flight and increases fuel efficiency. Traditional flaps have been replaced by a shape morphing control surface with the capability to perform the large angular deformations required for landing and take-off.

Keyword. Flexible wings, aerodynamic performance, aircraft design optimization, aeroelastic wings, lift-to-drag ratio.

1. INTRODUCTION

A radio-controlled aircraft (often called as RC aircraft or RC plane) is a small flying machine that is controlled remotely by an operator on the ground using a hand-held radio transmitter. The transmitter communicates with a receiver within the craft that send signals to servomechanisms (servos) which move the control_surfaces based on the position of joysticks on the transmitter. The control surfaces in turn affect the orientation of the plane. The design of RC plane involves aerodynamics, woodworking, composite materials, electronics, mechanics, small motors, drafting, artistry, and club activities practically all at the same time. The model is a real aircraft which flies and operates by the same principles as its full-scale counterpart. The only difference is size and weight. Models fly at anywhere between 20 and 150 MPH. These vehicles need lot of space to fly in the air and they require a learned skill to be controlled properly. Now-a-days government and military organizations are also using RC aircraft for experiments, gathering weather readings, aerodynamic modeling and testing. Perhaps, the most realistic form of Aeromodelling, and its main purpose to replicate full-scale aircraft designs from aviation history, for testing of future aviation designs. There are several types of RC planes and out of which we have chosen Radio-control scale aircraft.

2. BASE DESIGN

. The flexible wing structure is designed using the software CATIA (VERSION V5R19). traditional wings surfaces are replaced with flexible wings with shape-changing control surfaces. And this is made possible by covering the surface with rubber sheet and making it an aero elastic wing. The analysis is carried out on the ANSYS. The advantages of the flexible wing are that they are automatically controlled along the wind direction. The flexible surface adjusts the curvature of the wing's trailing edges to deliver an optimal lift-to-drag ratio throughout the flight condition. Flexible wing can smoothly adjust its camber to minimize drag during flight. This can be achieved by twisting the wing's trailing edges in just the right way so as to reduce the loads caused by turbulence and thus minimize the movement transmitted to the fuselage. This twisting would be done automatically by a sophisticated flight control system.

3. DESIGN SPECIFICATIONS

A trainer aircraft basically will have a high wing design, simple sturdy construction, excellent plans and instructions having high stability in the air in order to make flying easy. Parameter selection changes for each type of aircraft. Usually the only assembly to be done is joining the wing halves, adding the tail surfaces, mounting the radio system, engine and landing gear, and connecting the control surfaces Another consideration when choosing to fabricate first plane is how many control functions or channels to use. Trainer aircraft are available in both three channel and four channel configurations. Most aircraft fly with four functions, these being the Rudder, Elevator, Throttle, and Ailerons. Trainers, however, can also fly without the use of ailerons.

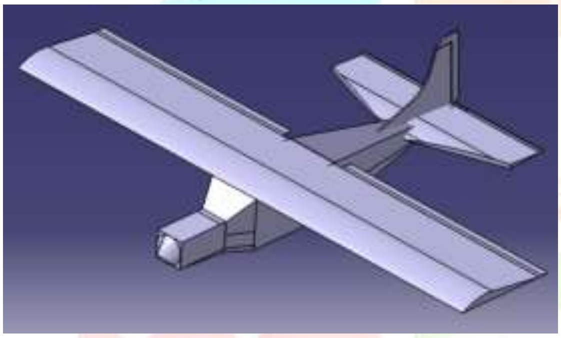

Figure 1.Design of RC Plane

Table 1. Design specification of a RC plane with flexible wing

PARAMETERS	VALUES
Maximum take of weight	2kg
Empty weight	1.5 kg
Length	1055 mm
Thrust weight ratio	2.5 kg
Wing span	1500 mm
Vertical stabilizer	200 mm
Type of engine	2 Stroke nitro Engine
Horizontal stabilizer	600 mm
Engine size	0.46
Range	1.25 km
Cruise velocity	130 km/hr

4. Boundary conditions

Flow of air is considered to be incompressible and subsonic. The free stream air flow has been kept 20 m/sec and the effect of temperature has been neglected. The density of air is 1.225 kg/m^3. The operating pressure is 1.01 bar. The absolute viscosity is 1.789 * 10^{-5}kg/m-s. The data have been obtained at different angle of attack from -3° to 15° with 3° steps.

Table 2 coefficient of lift

Angle of attack	Co-efficient of Lift
-3	-0.192
0	0.007755
3	0.21
6	0.41
9	0.6072
12	0.8064
15	1.0532

Angle of attack	Co-efficient of Drag
-3	-0.025811
0	0.017925
3	0.052527
6	0.091281
9	0.1297
12	0.16825
15	0.19408

5. Analysis carried out on ANSYS

Case 1.Comparison of angle of attack with lift co-efficient

The variation of lift co-efficient with angle of attack at 20m/sec at different angle of attack is shown in fig.4.3. The zero lift angle has been found at -3^o angle of attack. Then the lift co-efficient increases linearly with the increase of angle of attack up to approximately 15^o. In other words, the lift co-efficient increases linearly with the increase of angle of attack up to 15^o. As such the stalling angle is found at 15^o. It is also observed that the C_{Lmax} for this models approximately 1.05.

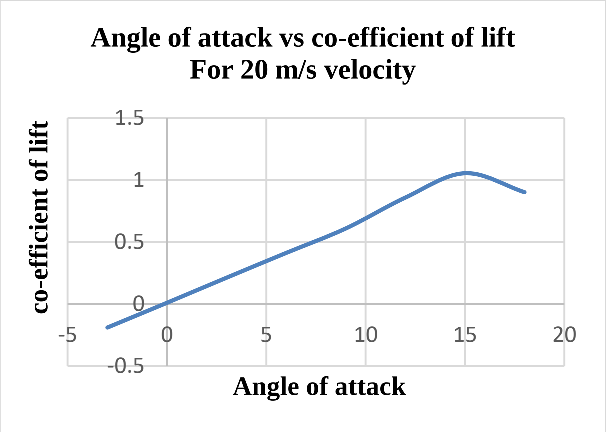

Fig.2.1 Lift co-efficient with angle of attack

CASE 2.Comparison of angle of attack with drag co-efficient

The variation of drag co efficient with angle of attack at 20 m/sec at different angle of attack is shown in fig.4.4. The shape of the drag co-efficient vs angle of attack curve is found linear. As such, the drag co-efficient increases with the increase in angle of attack. The value of drag co-efficient at 15 angle of attack is found 0.2.

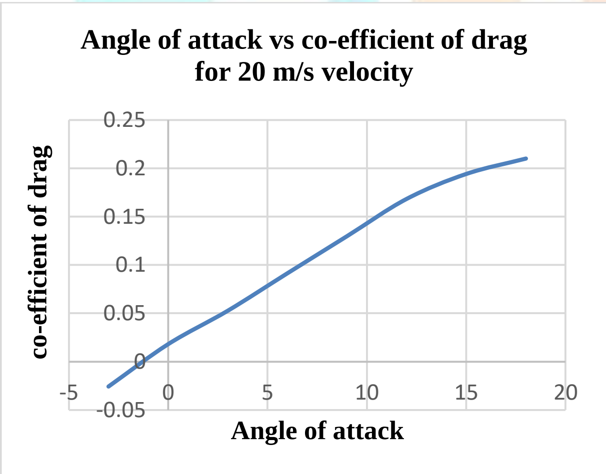

Fig 2.2 drag co-efficient with angle of attack

CASE 3.Comparison of angle of attack with lift co-efficient & drag co-efficient

The comparison graph for angle of attack, co-efficient of lift and co-efficient of drag for 20 m/s is shown in fig.4.5. From this graph we could observe that drag is less than the lift. Drag co-efficient is found more due to increase of induced drag for trailing edge vortices from airfoil shaped fuselage. It is because flow separation starts earlier.

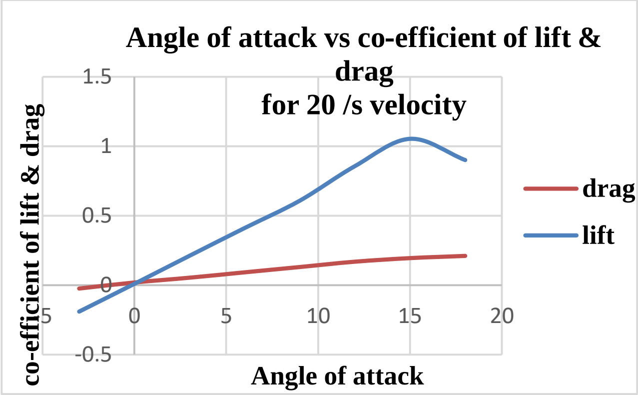

Fig 2.3 drag co-efficient and lift co-efficient with angle of attack

CASE 4. Lift to drag ratio curve

The lift to drag ratio curve of airfoil shaped fuselage withbicambered wing UAV is shown in fig.4.6 and it is found less for our model due to increase of induced drag for trailing edge vortices from the airfoil shaped fuselage. But increased a significant amount of extra lift from its wing due to bicamber shape.

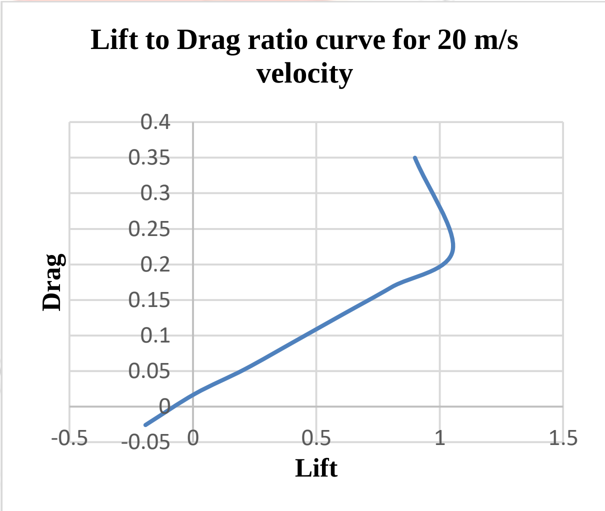

Fig.2.4 Lift to drag ratio curve

The investigation of flexible wing of an RC plane has been carried out at 20m/sec and compared with airfoil shaped wing with cylindrical fuselage UAV as referred in journal [12]. The angle of attack has been varied from -3° to 18° with 3° steps. The stalling angle for our design is found at about 15° for both models. The values of C_{Lmax} and C_{Dmax} with stall angle for both models is tabulated below in table 5.1.

Table 3. Aerodynamics values for both configurations

Configuration	Stall angle	CL max	CD max	L/D Ratio
Conventional UAV	15^o	0.94	0.144	6.57
Proposed UAV	15^o	1.05	0.19	5.10

6. CONCLUSION

The literature survey has been carried out completely to study the overall performance of the flexible wing structure installed in an airplane. The traditional flaps and aileron control surfaces are made flexible by covering the section with a rubber skin and making it an aeroelastic wing. As a result, there will be increase in fuel efficiency and lift-to-drag ratio. The morphed wing is modeled using CATIA (version -V5R19) software.

In phase two the complete simulation and fabrication work will be carried out and test flight will be conducted successfully.

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