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A Review on Morphed Wing for Unmanned Aerial Vehicles

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Abstract: This article presents a review on morphed twisted wing model for UAV. Twisted wing has a large potential to improve the overall UAV performances. This review discusses the most prominent examples of twisted wing concepts with applications to three-dimensional wing models. Twitted wings indicate the ability to transform shape or structure. The entire wing twisted and acting as an aileron and flap on the plane, creating lift and roll. The main focus is to discuss the advantage of twisted wing model.

Keywords: Twisted wing, Morphed wing, UAV, Seamless wing, Aeroelastic wing.

I. INTRODUCTION

The Twisted wing technology approach is a new design for the UAV. Most of the UAV don't use the wing for roll and lift. Here the entire wing act as the flaps for UAV. The wing twisted and produce lift and roll instead of convectional wing flaps. Recent developments in SMART materials can overcome these limitations and enhance the benefits of analogy design solutions. [15] presented an inventory of intelligent structures and integrated system. Designing a transformative aircraft using smart materials is a multidisciplinary problem. The challenge is to design a structure that can not only withstand the specified load, but can also change shape to withstand a variety of load conditions. To reduce complexity and thus increase reliability, the drive system, consisting of the active materials, must be embedded in the structure. Ideally, the structure and the powertrain should not be distinguished, so that the system used for charge production and transport is also capable of changing shape. Besides the advantages of complexity, reliability and manufacturing cost, such a concept could also prove to be lighter.

The maximum Shape modification technology was developed for Military applications where more versatile vehicles are used Compensates for the added complexity and weight. Also, in recent years, the focus has become smaller aircraft (mainly unmanned aerial vehicles or UAVs) [12]. The tendency towards UAVs is due to higher efficiency Depends on requirements and quick delivery. When the aerodynamic load of the UAV is low also increases the number of potential morphing techniques. Except for variable-sweep and swing-wing concepts, most previous twisted wing concepts were applied to lightly loaded, relatively low-speed airplane designs [3]. The current review is to differentiate the convection type of wing and morphed wing to obtain the better lift and drag at lower angle.

II. AERODYNAMICS OF WING THEORY

Aerodynamics deals with the movement of air and the forces acting on objects that move in the air or remain stationary in the flow of air. The same principles of aerodynamics apply to both rotor and fixed-wing aircraft. The four forces that constantly act on an aircraft are weight, lift, thrust, and drag [4].

Weight is the force exerted on an UAV by gravity. The centre of gravity is the point at which the plane is hovering and balancing. the magnitude of this force changes only when the weight of the aircraft changes. Lift is generated by the air flowing over the wings of an airplane or the rotor blades of a helicopter. Lift is the force that overcomes the weight of an aircraft and lifts it into the air. Thrust is the force that moves an airplane through the air [11]. In a traditional fixed-wing aircraft, the thrust provided by the propeller propels the aircraft forward, and the wings provide lift. In helicopters, both thrust and lift are provided by the main rotor blades. Drag is the resistance of air as the aircraft passes through. Thrust moves the plane and keeps moving against air resistance. All devices designed to generate lift or thrust when guided in the air are airfoils. Airplane wings, propeller blades, helicopter main rotor blades and tail rotor blades are all airfoils[11-14].

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III. THE MORPHED WING STRUCTURE DESIGN

In demonstrated morphed wing design concept, most of them are use the trailing edge as twisting area. The wing model has been selected based on the variable condition inlet velocity, Reynolds number, span and area contains. Morphed wings allow the inner wings to slide to change the wingspan from the outer wing [20]. For this study, the half-span of the inner and outer wings was 1 m, the inner wing can be further extended up to 0.75 m. The structural solutions adopted to achieve variable span functionality include leading and trailing edge composite carbon fibre reinforcements and evenly spaced composite carbon fibre reinforcements along the span to replace convectional ribs. It consists of a hollow outer wing that supports the load [7]. In the light of the review of existing literature, they use NACA 0012, NACA0015, S9000, etc. The main goal of this task is to design a UAV with twisted morphing wings and camber morphing horizontal and vertical rear stabilizers. An UAV that can complete flight missions without the use of separate control surface such as ailerons, elevators and rudder. For simplicity, a rectangular planar shape was chosen for the wing and tail stabilizers. Due to the very low expected flight altitude of UAVs, standard sea level conditions (SSL) (air density ρ = 1.225 kg / m3, barometric pressure P = 101.3 kPa, temperature 15 ° C) were also adopted at the time of design. UAV weights are one of the most important parameters that affect the design. After the main concepts for morphing wings and tail stabilizers were enveloped, spreadsheets were created and continually updated to include structural components, engines, electronics, and all other components that will be installed in the UAV. The total weight of the UAV was calculated based on the weight of the UAV and controls etc [19].

IV. ANALYSIS OF MORPHED WING

Several discrete models have been constructed to simulate the wing in different span configurations to computationally represent the morphed wing and assume quasi-static behaviour. These configurations represent the behaviour of the wing under static conditions. The model shows the FEM and CFD meshes first used to morph the dimensions of the wing structure, then used for aerodynamic performance evaluation, and used for coupled field analysis using Ansys CFX software. Combined field analysis, or multi-field analysis, is a combination of analyses in different engineering disciplines where the inputs of one field interact to solve global engineering problems that depend on the results of another field. In fluid structure analysis, fluid pressure deforms the structure, which changes the fluid solution, which requires interaction between the two physical fields to achieve a convergent solution [15].

The CFX solver discretizes the Navier-Stokes equations on the mesh elements and produces a set of nonlinear equations for each variable of each mesh node. These equations are solved by the coupled solver. The solution process is iterative, and each iteration (stationary problem) is treated as a pseudo-time step. It stops when either:

A pre-determined convergence criterion is met

OR the maximum number of timesteps is reached

OR the user stops the run, using either the CFX-Solver Man-ager or the cfx5stop command.

The first two criteria for these conditions can be user-defined in CFXPre. Steady-state simulations are performed as a series of pseudo-time steps. The time step size is determined by the time step setting in the CFXPre solver control form. See Solver Control for more information [22].

Table 1. CFX solver input file option.

Input File	Definition File	Definition File	Results File
Initial Values File	-	Results File	-
Circumstance	New Run — all information is available in Definition File	Restarting analysis from previous results	Continuing analysis for a further number of iterations
Consequence	New Results File contains info from iteration 1	New Results File contains info from iteration (*n* +1)	New Results File contains info from iteration (*n* +1)

V. RESULT AND DISCUSSION

The CFD post process result shows the CL and CD values for morphed wing. The same procedure has been carried out for the convectional rectangular wing and the CL and CD values for normal wing are derived. The variation of L/D ratio with angle of attack for straight wing and morphed wing. it is observed that the L/D ratio is much better for morphed wing. Using the literature below data are derived [3].

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Table 2. Coefficient of lift and drag along the angle of attack

S.no	Angle of attack	C_D for normal wing	C_L for morphed wing
1	0	0.2336	0.2336
2	1	0.2346	0.2652
3	2	0.2649	0.2968
4	3	0.2862	0.3248
5	4	0.3075	0.3958
6	5	0.3287	0.3911
7	6	0.3499	0.4224

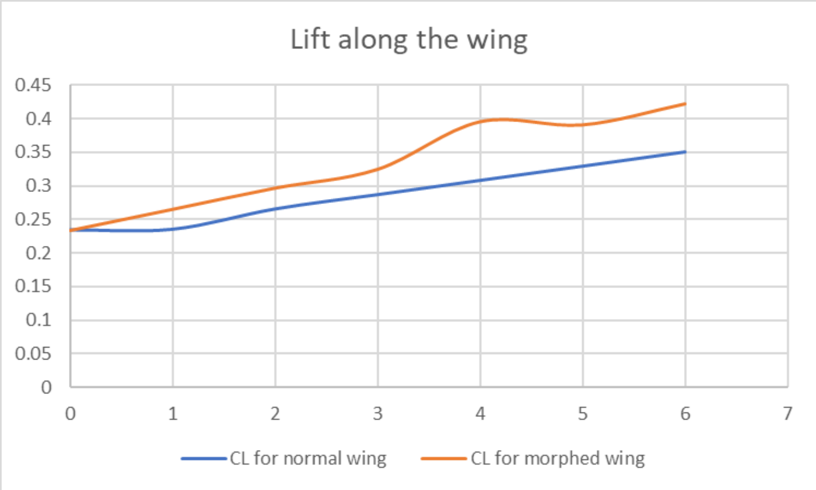

Fig. 1 Coefficient of lift and drag along the angle of attack

VI. Conclusion

Thus, the aerodynamic performance of a morphed wing having large lifting area compared for various parameter like lift, drag, induced drag and lift to drag ratio for different angle of attack with the same of normal wing using computational fluid dynamics. With these results we found that the L/D ratio for morphed wing is greater than straight wing at all angles of attack. However, from this study it is very well understood that the morphed wing possesses better aerodynamic performance than the conventional straight wing. The study clearly shows that the morphed Wing structure applicable to a lightweight UAV.

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