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Numerical Analysis of Pressure Distribution Conventional and Telescopic Wing at Different Angle

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Abstract: *Morphing of wing is generally defined as the process of changing the structure to attain high performance. The objective of morphing activities is to develop high performance aircraft, with wings changing its shape and performance substantially during various flight conditions. Morphing of wing can be generally classified as resizing along camber, variable camber wing, variable dihedral wing, wings of varying sweep, telescopic wing, etc. Specifically, morphing along span-wise results in reduction of induced drag, allowing for increased range or endurance. In this project, the aerodynamic characteristics of the telescopic wing model are investigated. In order to predict the aerodynamic characteristics of the telescopic wing, the numerical investigation is carried out. The inferred performance of the telescopic wing is then compared with the performance of the conventional wing. The inferred results exhibits the lift to drag ratio of the telescopic wing is more than the conventional wing.*

Keywords: *Conventional wing, Telescopic wing, Induced drag, Endurance.*

INTRODUCTION

Serious efforts to master the air were initially taken by Leonardo da Vinci towards the end of the 1400s. He systematically studied bird and bat wings and observed their flight. Based on these observations, he first tried to build a man-powered flapping machine. But the first aviation trails were made by Otto Lilienthal in late 1800's. He studied the gliding flight in birds and based on these observations constructed gliding planes similar to today's hand-gliders. A morphable/adaptive wing is the one that can changes its geometry to accommodate multiple flight regimes. The ideal use of an adaptive strategy allows the wing to vary its geometric parameters in flight during encounters in suitable of changing flow conditions such as wind speed or direction. Several approaches have been proposed over the years both in theory and in experiments that try to evaluate the bird wing characteristics. The primary aim of these researchers was to develop different lift generating mechanisms which could be broadly classified as fixed wing and rotorcraft morphing approaches. Another approach towards the lift generating mechanisms is being investigated through the flapping wing technology. The following work derives inspiration from the fixed wing approaches. A variable aspect ratio wing would try to incorporate the high speed and maneuverability benefits of low aspect ratio wings, and increased range and fuel efficiency from the large aspect ratio ones.

Review of Literature

The process of reading, evaluating, classifying and comparing the prior research studies, summarizing them and critical analysis of scholarly materials about a specific topic is known as a literature review. From the literature review the development of telescopic wing and their aerodynamic characteristics are studied. Ahmed.M.R and Sharma.S.D (1) investigated the flow characteristics over a symmetrical airfoil NACA 0015 are studied experimentally in a low speed wind tunnel. The pressure distribution on the airfoil surface was obtained, lift and drag forces were measured and mean velocity profiles were obtained over the surface. Andrew Ning.S and

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IlanKroo (2) a studied about the conceptual wing design analysis methods are combined with numerical optimization to find minimum-drag wings subject to constraints on lift, weight, pitching moment, and stall speed. Tip extensions and winglets designed for minimum drag achieve similar performance, with the optimal solution depending on the ratio of the maneuver lift coefficient to the cruise lift coefficient. The concept of the Aerodynamic–Structural Design Studies of Low-Sweep Transonic Wings by John C. Vassberg & SriramShankaran (3) they investigate the current generation of civilian transport aircraft are typically designed with a moderately high swept wing.

Aircraft Wing Design

A wing is an appendage with a surface that produces lift for flight or propulsion through the atmosphere, or through another gaseous or liquid fluid. A wing is an airfoil, which has a streamlined cross-sectional shape producing a useful lift to drag ratio. A wing's aerodynamic quality expressed as lift-to-drag ratio. The lift a wing generates at a given speed and angle of attack can be one to two orders of magnitude greater than the total drag on the wing. A high lift-to-drag ratio requires a significantly smaller thrust to propel the wings through the air at sufficient lift.
Table1: Specification of Wing Model

Specification	Range
Length	250mm (50mm retractable wing)
Chord length	150mm
Camber	100mm
Thickness	21%
Airfoil type	Symmetrical
NACA Series	0021

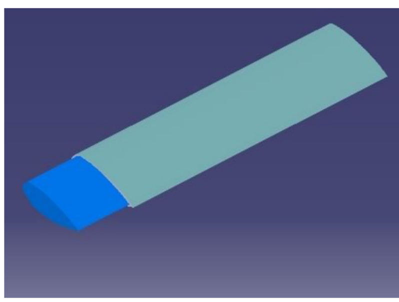

Figure1: Telescoping Wing

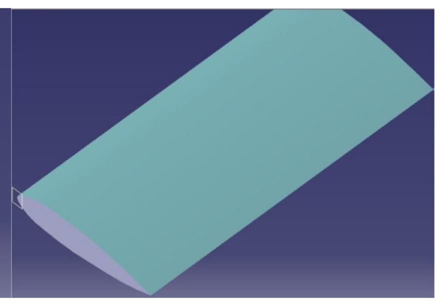

Figure2: Conventional Wing

Airfoil Cross-Section Shape

The shape of the wing cross-section determines the pressure distribution on the upper and lower surfaces of the wing. The pressure distribution integrated around the wing is the lift force. The lift force normalized by the wing area and dynamic pressure is the lift coefficient (CL). Linear airfoil theory indicates that a 2-D airfoil section has a lift coefficient, CL, which is linearly proportional to its angle of attack.

Aerodynamic Terminology

The aerodynamic center is the point at which the pitching moment coefficient for the airfoil does not vary with the lift coefficient. For the symmetric airfoils in subsonic flight the aerodynamic center is located approximately 25% of the chord from the leading edge of the airfoil. This point is described is described as the quarter-chord point. The aspect ratio of a wing is defined to be the square of the span divided by the wing area. Aspect ratio is a measure of how long and slender a wing is from tip to tip. For a rectangular wing, this reduces to the ratio of the span to the chord length. The critical Mach number of an aircraft is the lowest Mach number at which the airflow over any part of the aircraft reaches the speed of sound.

Numerical Analysis

This chapter explains about the numerical analysis of the conventional and telescopic wing. The numerical analysis of the conventional and telescopic wing is carried out by Solid Work COSMOS software. The numerical analysis is carried out for 3-D model of the

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telescoping wing. The pressure contours and the velocity contours are obtained by the contour options from the figures are given below.

Pressure Distribution

The pressure distribution is the contour which shows the distribution of pressure in and around the object to clearly visualize the performance prediction. Figure 3 shows the Pressure Distribution of conventional and telescopic wing at various angle of attack. In Figure 3(a) and (d) the pressure is very high at the leading edge. The pressure over the lower and upper surface is equal. There is no lift force at zero angle of attack. Figure 3(b) and (e), shows the Pressure Distribution over the wing at 10^0 angle of attack of conventional and telescopic wing. In Figure (e) the pressure is high at lower surface and low at upper surface. Hence, there is creation of lift in 10^0 angle of attack. In Figure (e), the pressure at the lower surface is more in telescopic wing when compared to the conventional wing. Figure 3(c) and (f) shows the Pressure Distribution for the wing at 15^0 angle of attack of conventional and telescopic wing. From Figure 3(c), the pressure is maximum at lower surface and minimum at the upper surface. Hence, there is creation of lift at 15^0 angle of attack. From Figure (f), the pressure is high at the lower surface and low at the upper surface. Hence, at 15^0 angle of attack, the pressure over lower surface is more in telescopic wing, when compared to the conventional wing.

Results and Discussions

This Chapter discuss about the comparison of numerical analysis of conventional and telescopic wing. The Telescopic and the conventional airfoil were tested in open-circuit wind tunnel and also the results are compared with the numerical methods. The pressure contours illustrates that the pressure over the upper surface is lower than the pressure over the lower surface of the conventional wing. But for the Telescopic wing, the pressure over the upper surface is higher than the pressure over the upper surface.The co-efficient of lift for the telescopic wing gets increased when compared to the conventional wing. Pressure Distribution play a major role in the analysis of aircraft wings. The aircraft can fly with the application of Bernoulli's equation which states that the pressure increase at some point in the flow velocity automatically decreases. For effective Performance Analysis, Pressure over the aircraft wings is mainly required.

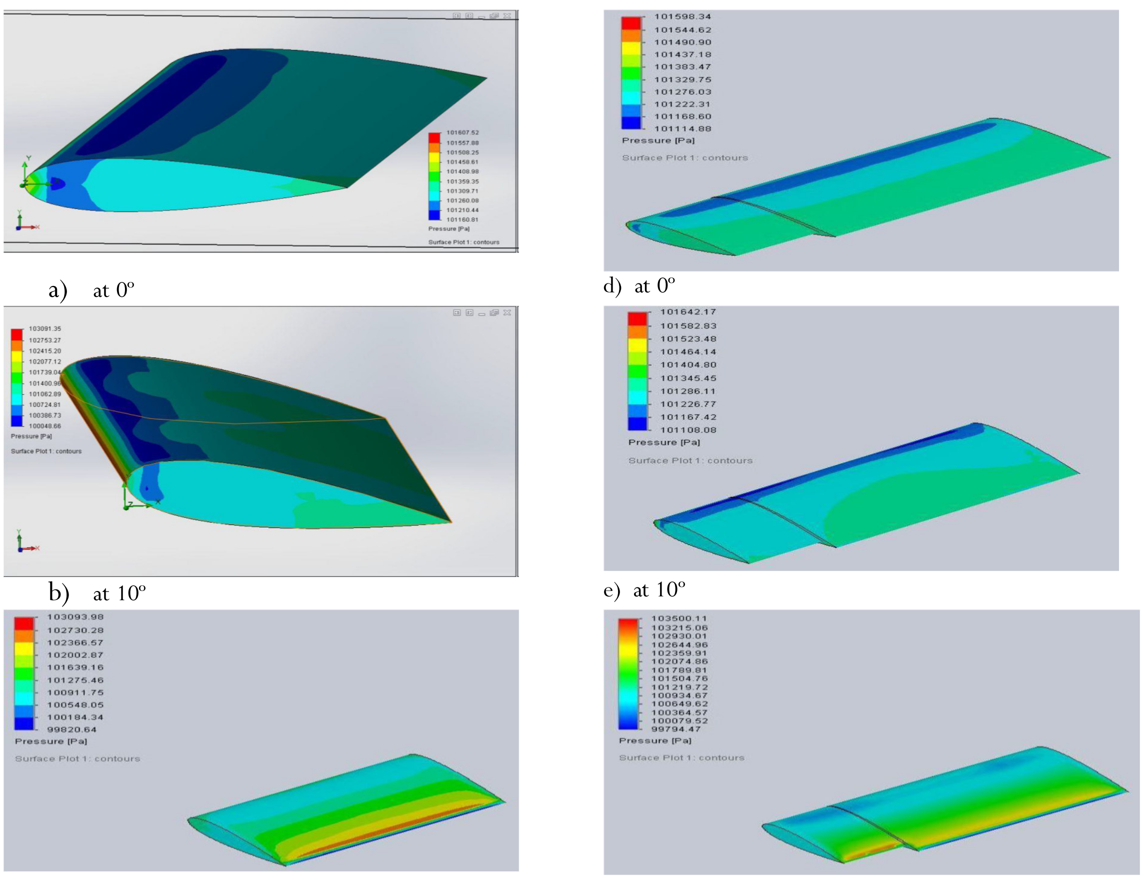

Figure 3: Pressure Distribution of Wing

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.Table 2: Comparison of CL of Conventional Wing with Telescopic Wing

Angle of attack	CL	
	Conventional wing	Telescopic wing
0^0	0	0
10^0	1.09	1.20
15^0	1.63	1.71

Conclusion

The numerical investigation of telescopic wing in order to predict its aerodynamic characteristics is carried out in this project. The performance of telescopic wing is attained with the suitable actuator for the actuating purpose. The performance of telescopic wing is better when compared to the conventional wing. The experimental investigation is also carried out in the open circuit subsonic wind tunnel. The experimental and analytical results for CL against angle of attack are plotted for both the conventional and telescoping wing. In telescopic wing, the value of CL is increased because of area is increased by retractable.

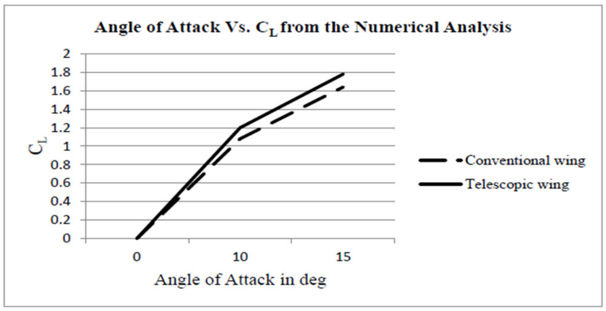

Figure 9: Angle of Attack Vs. CL from the Numerical Analysis

wing and that is controlled by using the gear mechanism (rack & pinion) and also by the hallow structure of the main wing the weight of the wing gets reduced. Thus, the telescopic wing gives the better performances compared to the conventional wing. In future, the telescopic morphing mechanisms are to be developed for the UAV's and MAV's with the utilization of high performance as well as light weight smart materials

References

1. Ajaj R.M, Friswell M.I, (2012), 'Span Morphing: A Conceptual Design and Structures', Structural Dynamics and Materials Conference, pp. 1-8.
2. Ahmed M.R and Sharma S.D, (2001), 'An investigation on the aerodynamics of a symmetrical airfoil in ground effect', Aeronautics R&D Board, Ministry of Defense, Govt. of India, under project No. Aero/RD-134/100/10/2000-2001/1108, pp. 12-18.
3. Andrew Ning. S and Ilan Kroo , (2010) 'Multidisciplinary Considerations in the Design of Wings and Wing Tip Devices', Journal of Aircraft Vol. 47, No. 2, pp. 22-26.
4. Coiro.D and Grasso.F, (2009), 'Design and Testing of a Multi-Element Airfoil for short-Takeoff and landing of Ultra light Aircraft', Journal of Aircraft 0021-8669 vol.46 no.5 , pp.1795-1807.
5. Darren Hartl Dimitris C. Lagoudas, (2008), 'Aerospace applications of shape memory alloys', Aerospace Engineering Department, Texas A & M University College Station, pp. 2-10.
6. Dianna G.N, (2009), 'Development of SMA based actuator mechanism for deployment of control surfaces', Proceedings of ISSS, pp. 131 -138.
7. Georges.T, (2009), 'Design diagram for linear SMA actuators integrated in a morphing wing structure', Ecole de technologies superieure (ETS), pp. 112-118.
8. Joao R.C. Mestrinho, Joao M.I. Felício (2010), 'Design Optimization of a Variable-Span Morphing Wing', 2nd International Conference on Engineering Optimization, pp. 1-4.
9. John C. Vassberg , Sriram Shankaran,(2010) , 'Aerodynamic–Structural Design Studies of Low-Sweep Transonic Wings', Hydro-Aero Consulting Group, Journal of Aircraft Vol. 47, No. 2, pp. 4-8.
10. John.D.Anderson, (2003), 'Fundamental of Aerodynamics', McGraw-Hill Publications.
11. Livier Gonzalez, (2007), 'Morphing wing using shape memory alloy: A conceptual proposal', University of Puerto Rico at Maya.
12. Mamou.M, (2010) 'Aerodynamic performance optimization of a wind tunnel morphing wing design UAV', International congress of the Aeronautical Sciences, pp. 1-10.

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