Aerodynamic Performance Analysis of a Variable Sweep Wing for Commercial Aircraft Applications

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Abstract - *This study presents a detailed study on wing and its configurations and the morphing techniques for the wing. The morphing methods of the wing such as variable chord, variable span variable cambers have been studied in detail. In this study in detail about the effects of morphable sweep wing, the commercial aircraft wing has been designed and it's been modelled using the solid works software. To study the aerodynamic performance the wing, the wing has been analysed in ANSYS Fluent software and the results are interpreted in detail to analyze the effect of wing and its shapes. From the results it's been clear that at low speed (Mach=0.8) straight wing has high L/D ratio and at the sonic speed (Mach=1) sweep wing has higher L/D ratio and in Supersonic Speed (Mach=1.2) delta wing tends to have higher L/D ratio. Based on these results the wing can be morphed to the configurations to obtain a better performance in each flight regime. Based on these morphing, aircraft performance can be improved in all flight regimes.*

I. Introduction

In recent times designing an aircraft requires a multidisciplinary approach that encompasses some aeronautical disciplines, including structures, propulsion systems, aerodynamics, and aircraft controls [1]. In swept wing technology the aero plane wings square measure swept back at AN approximate angle of some degrees. On fighter styles, the addition of vanguard extensions, conjointly serve to feature raise throughout landing and cut back the matter. When a particular sort of mission is needed, there's sometimes a perfect configuration of the craft to accomplish it [2]. Therefore, Associate in attention to aircraft's performance is greatly improved with the addition of morphing parts that permit it to realize that ideal configuration for varied flight conditions and missions [3]. Roth et al used wing - morphing as an independent variable approach in order to identify the most important geometric features that could affect the performance of the aircraft [4]. Bilgen et al. is applied a control concept to the optimization of changeable sweep in maneuvering flight [5]. Yan et al presented one amongst the methodologies that may be adapted to style variable wing pure mathematics and its practicality [6]. Liu et al studied based on the variable forward-swept wing configuration, which utilizes a variable forward-swept wing mechanism with a double slideway [7]. Molinari et al found that aerodynamic characteristics have been obtained in flight for the X-29A airplane for speed from 0.4 to 1.3 mach [8]. Patil et al attempted to find out the structural behavior of the wing imperiled to flowing loads through the voyage [9].

Kim et al presented drag is taken into account to be one in every of the key concern within the craft, whereas increase within the drag leads to decrease in aircrafts performance [10]. From literatures review, to enhance the performance by drag reduction varied analysis advancements area unit performed; out of that wing morphing is one amongst it. To develop high performance craft with wings designed to alter wing sweep angle and improve performance considerably throughout flight to form multiple-regime, aerodynamically-efficient, shape-changing craft. Drag is considered to be one of the major concern in the aircraft, whereas increase in the drag results in decrease in aircrafts performance. To improve the performance by drag reduction various research advancements are performed, out of which wing morphing study is considered in this paper.

II. METHODOLOGY

The concept of a morphing wing is able to adapt a wing for different aerodynamic character during flight**.** An aerodynamic feature added to aircraft wings to adjust lift distribution along the wing [5, 6]. Smart materials are having good properties that can be significantly changed in a controlled fashion by external.

Modeling

In these work three types of configuration to complete the variable swept wing model by using SOLID WORKS software. They are- Trapezoidal wing, swept back wing and delta wing. In this process geometry for the wing is imported from the CAD package to the design modeler. Now a domain for the model is created for the analysis purpose [7]. The imported model of wing with configuration is shown in figure 1. The domain is created over the wing with the following parameters: Length of the domain is 140 m, Height of the domain 140 m, Width of the domain 70m, Distance from inlet to wing 70 m, By considering these parameters the wing domain for analysis is created as shown in the figure 2.

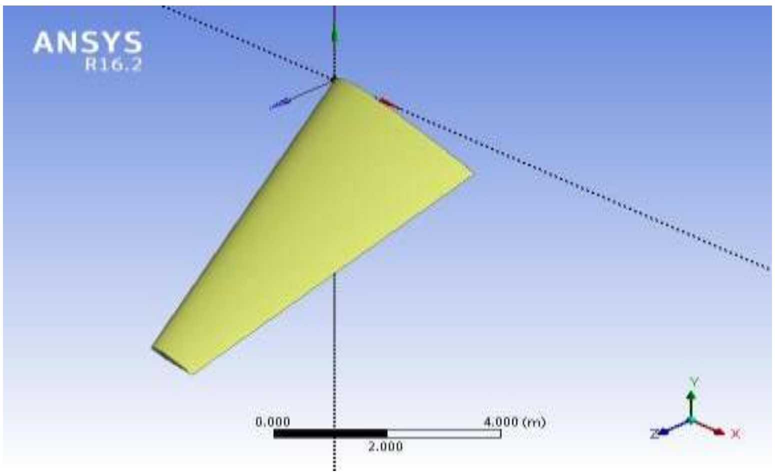


Figure 1: Imported model of wing

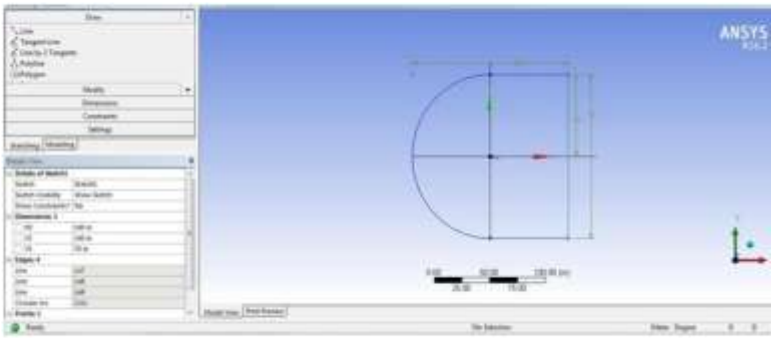


Figure 2: Domain of the model

In the simulations, the aircraft component surfaces were discredited with triangular mesh elements. At initial level a mesh with face meshing over the wing with blended winglet is defined with the parameters are given in Table 1. The meshed image of the wing is shown in figure 3. From this condition we have obtained a total number of nodes as 44228 and total number of elements as 242823. The detailed mesh image is shown in the figure 4. It‘s the zoomed view of the mesh which is located over the wing model. Next to the discretization process the domain must be named for defining the boundary conditions [7-9]. The naming for the domain is as shown in the figure 5.

Table 1: Mesh Conditions

Conditions	Values
Curvature angle	18°
Minimum Size	0.08 m
Maximum Face Size	10.467 m
Maximum Size	20.934 m
Growth Rate	1.2
Min. Edge Length	1.076 m
Refinement in Wing	2

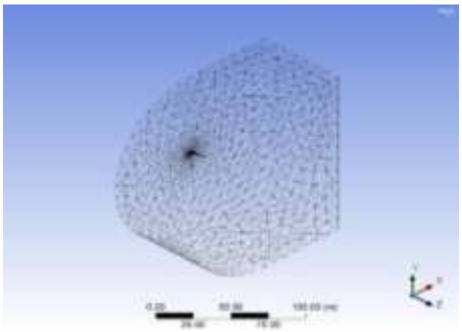


Figure 3: Mesh Model

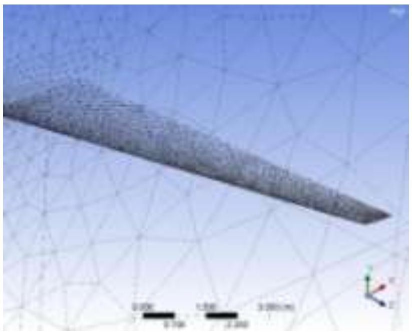


Figure 4: Mesh over the wing

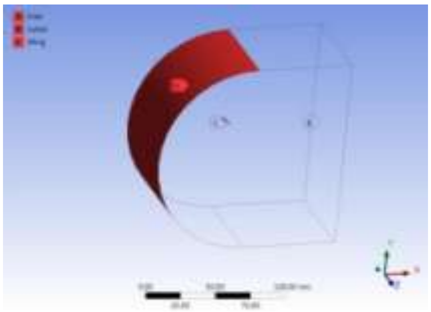


Figure 5: Naming of domain section

The problem of wing with winglet numerical analysis requires the solver settings to be completed before starting the simulations. The fluid properties were calculated taking into account the temperature and density of the average ambience condition [10].

III. RESULTS AND DISCUSSION

The analysis for the wing section was carried out for three different velocities and with three different configurations is presented in figure 6. The analysis was performed for Mach number of 0.8, 1 and 1.2. The results for these are discussed. The flow analysis and lift and drag for wing with different configurations are given in Table 2 and 3.

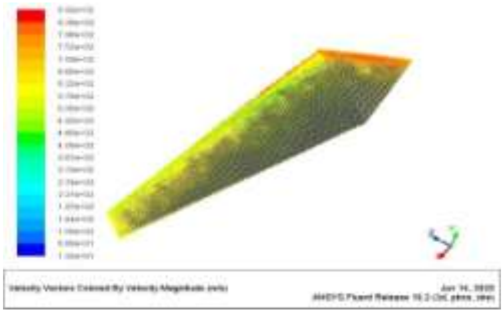
Table 2: Lift and Drag for wing with Different Configurations

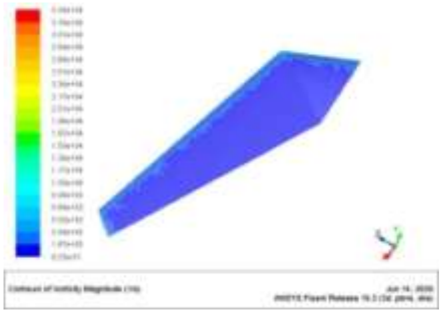
Case	Case-1			Case-2			Case-3		
	C_L	C_D	L/D	C_L	C_D	L/D	C_L	C_D	L/D
Straight	94.1	11.4	8.2	92.39	14.23	6.4	92.7	14.1	6.5
Sweep	101.31	13.06	7.7	105.4	12.76	8.2	105.8	12.63	8.3
Delta	68.67	13.8	4.9	112.7	20.29	5.5	121.65	12.14	10.02

Table 3: Flow Analysis

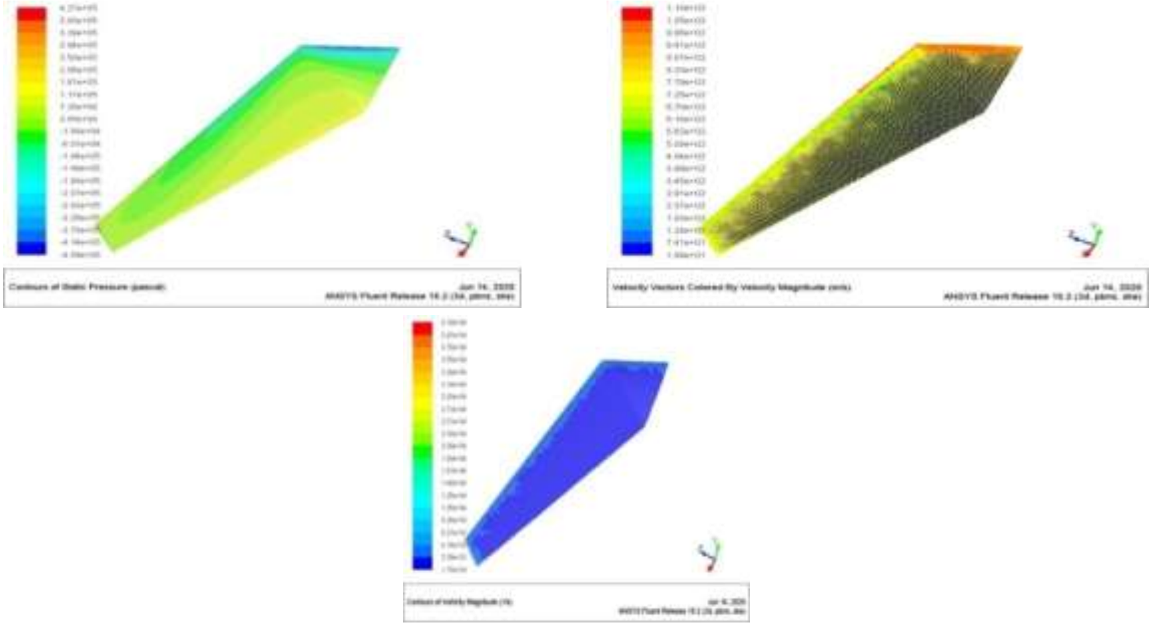
Case	Case-1			Case-2			Case-3		
	Pmax	Vmax	Vortices	Pmax	Vmax	Vortices	Pmax	Vmax	Vortices
Straight	$2.93x10^5$	1240	$1.95x10^4$	$4.55x10^5$	1530	$2.47x10^4$	$6.51x10^5$	1820	$2.98x10^4$
Sweep	$2.75x10^5$	1010	$2.02x10^4$	$4.31x10^5$	1280	$2.59x10^4$	$6.19x10^5$	1540	$3.14x10^4$
Delta	$2.73x10^5$	883	$3.34x10^4$	$4.27x10^5$	1100	$4.18x10^4$	$6.16x10^5$	1540	$4.2x10^4$

For Delta wing Case 1

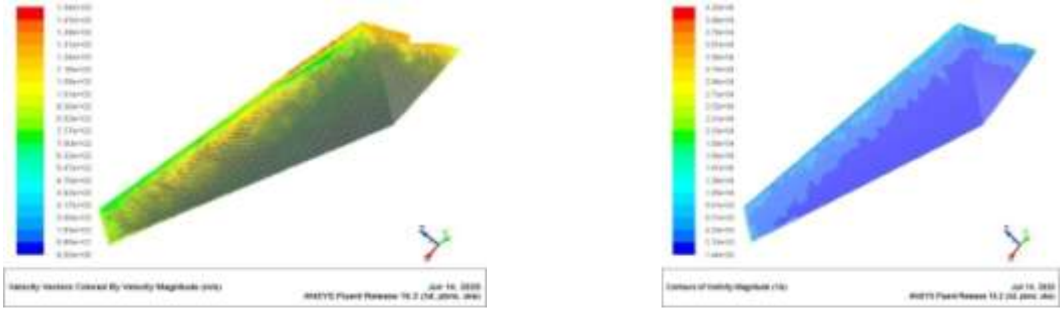




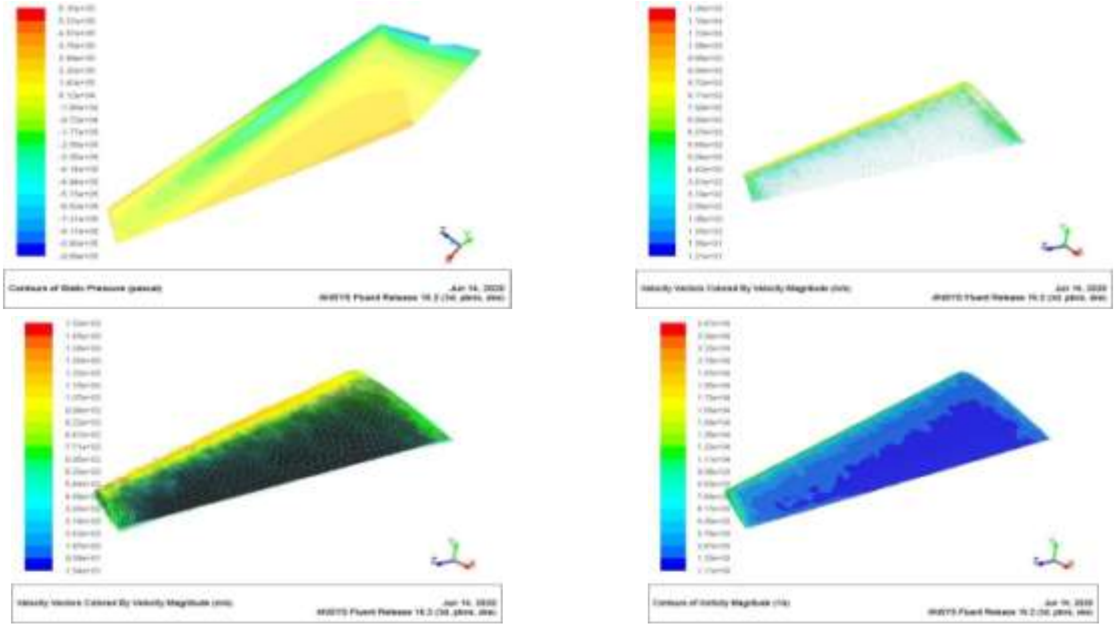
For delta wing Case 2



For delta wing Case 3



For Straight wing



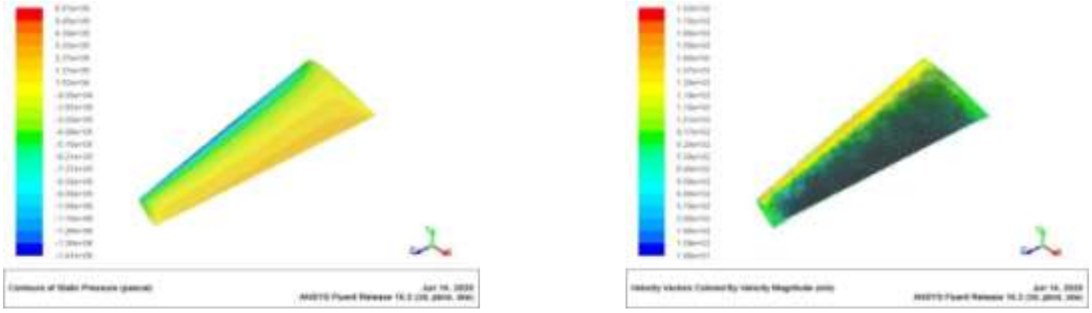


Figure 5: Analysis for the wing for different velocities and with different configuration

IV. CONCLUSION

In this work the wing configuration such as swept wing has been studied in detail. The morphing methods of the wing such as variable chord, variable span variable cambers have been studied in detail. The effects of morphable sweep wing, the commercial aircraft wing has been designed and it‘s been modelled using the solidworks software. To study the aerodynamic performance the wing, the wing has been analysed in ANSYS Fluent software and the results are interpreted in detail to analyze the effect of wing and its shapes. From the results it‘s been clear that at low speed (Mach=0.8) straight wing has high L/D ratio and at the sonic speed (Mach=1) sweep wing has higher L/D ratio and in Supersonic Speed (Mach=1.2) delta wing tends to have higher L/D ratio. Based on these results the wing can be morphed to the configurations to obtain a better performance in each flight regime. Based on these morphing, aircraft performance can be improved in all flight regimes.

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