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Gunda Shiva krishna Prof.
Assistant professor Department of aerospace engineering Amity school of engineering and technology, Mumbai & amity university, Maharashtra, shivakrishna0206@gmail.com

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Modeling and Structural Analysis of Morphing Wing in UAVs

GUNDA SHIVA KRISHNA
Asst professor in Department of Aerospace Engineering
Amity school of engineering and technology
Amity University Mumbai
Shivakrishna0206@gmail.com

Kalyani Amar Mahindrakar
Student Department of Aerospace Engineering
Amity school of engineering and technology
Amity University Mumbai
kmahindrakar02@gmail.com

***Abstract*— Morphing structure enables an aircraft to alter its configuration in maneuver to operate effectively in a given flight reign. A continuous wing is utilized to reduce drag as the wing deformation is approximated more closely. With such wing morphing of skin supported with underlying truss structure, they are able to control the unsteady aerodynamic forces. This project seeks to expand and unravel the capability of an aircraft through the application of a reconfigurable "morphing" wing. In this project, the structural model of the morphing wing consists of primarily wing components designed in solid works. Structural analysis of wing components has been written to minimize wing deformation under aerodynamic load using ANSYS. With fixed geometry, the wing is allowed to analyze Fluid Structure Interaction (FSI) in Fluent. Smart materials which carry aerodynamic loads such as shape memory alloys, piezoelectric actuators, and shape memory polymers have been discussed briefly. Along these lines, this paper fills in as an abstract for scientists and designers endeavoring to get to know the current progressions and advancements in morphing wing technology**

Keywords-component; morphing wing ,airfoil 4412 ,NACA,ANYS, UAV ,WINGS ,STRUCTIRES, FSI

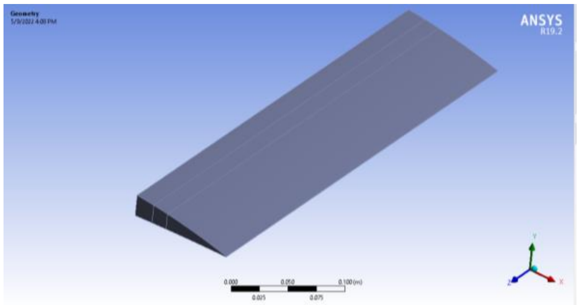
Introduction

Bio-inspiration from the birds or insects who can bend or twist their wings in order to achieve aerodynamic forces control, uplifted the concept of Morphing[1] Wing structure in aircrafts. The morphing method scope is broad in such a way that an optimal solution can be generated in various ways with respect to different kinds of mission profiles and flight regimes. Morphing systems consist of wing shape modifications, span or sweep angle or dihedral angle changes, airfoil camber changes and variations of the thickness distribution. Morphing is envisioned to increase the number of optimum operational conditions for a given aircraft which are traditionally limited for conventional wing configurations. Morphing system is practically more useful in Unmanned Aerial Vehicles (UAV)[2] because of its lightweight, less complexity in structure and noise reduction. Morphing technology on aircraft has grabbed attention over the last decade because of its development in the performance and efficiency over a wider range of flight conditions. Morphing wing technology shows high potential in decreasing aircraft fuel consumption as compared to conventional aircrafts. For example, Laminar flow technology has major contributions in the reduction of drag and flow separation. Morphing wings have requirements such as flexible skins that can withstand large deformations and have low in-plane stiffness. With the part of the trailing edge morphed, it is possible to minimize flow separation and drag. With advancement in smart materials especially, micro-fiber composites and programmable materials, morphing the selective parts is feasible and now we have materials which can get morphed using electrical signals or by other means. Shape memory alloys and adaptive materials are used in the design of the morphing wing in UAVs. Modeling of the NACA4412 wing is done in ANSYS. The impact of pressure on a dynamic morphing wing will be analyzed using Finite Structure Interaction (FSI) to gauge its behavior under specific circumstances. The work represented here contributes to the structural analysis and highlights use of smart materials in aircrafts as well. Morphing aircrafts

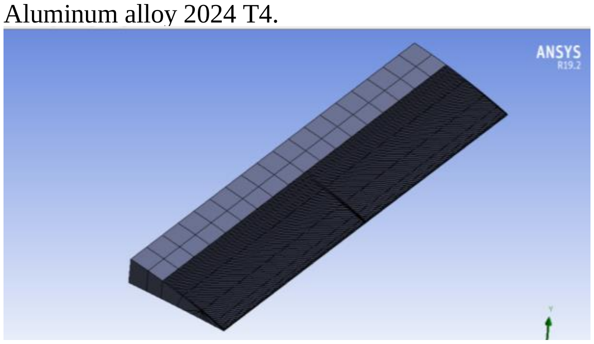
Morphing aerial vehicle is also defined as an aerial vehicle which has the ability to change its wing planform shape substantially during the flight. Changing the overall planform shape of the wings and/ or control surfaces will lead to an increase in the aerodynamic performance at each phase of the flight and extend the flight envelope of the aerial vehicle so that it can perform multi-role missions. With the help of increase in aerodynamic performance, fuel consumption of the morphing aerial vehicle will certainly be less compared to the conventional aerial vehicles

Modeling

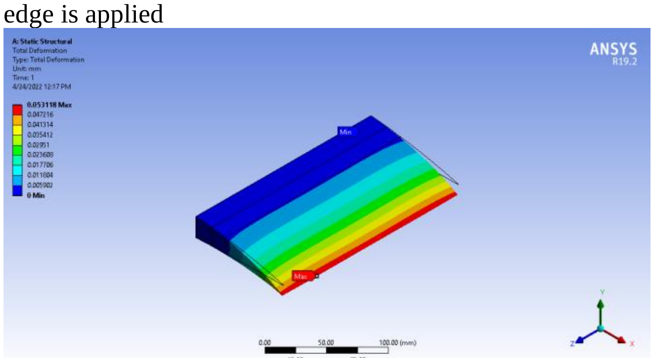
We have taken the coordinates of the airfoil are imported and the geometry is created to use for the simulation. Begin by downloading the file from airfoil tools website and saving it somewhere convenient. This file contains the coordinate points of a NACA 4412airfoil NACA 4412 in fluent, the geometry is created for the simulation. First, Pressure distribution is analyzed in Fluent. Open Fluent Geometry.



Meshing
Unstructured mesh of trailing part model has been created for avoiding complexities and errors. Material applied is Aluminum alloy 2024 T4.

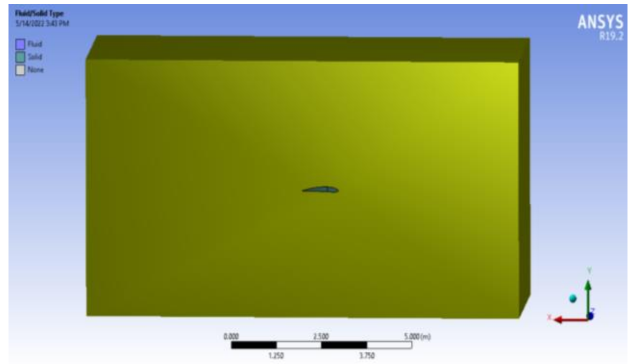


Numerical solution
1 MPa pressure load on the upper surface of the trailing edge is applied



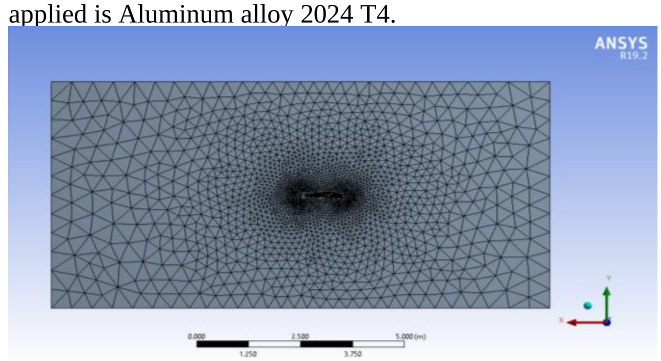
Total deformation of trailing edge of Morphing wing

Fluid Structure Interaction (FSI) of NACA 4412 in fluent the dimensions 6x3x3 m^3 which is a fluid domain and divide the wing face into leading and trailing faces

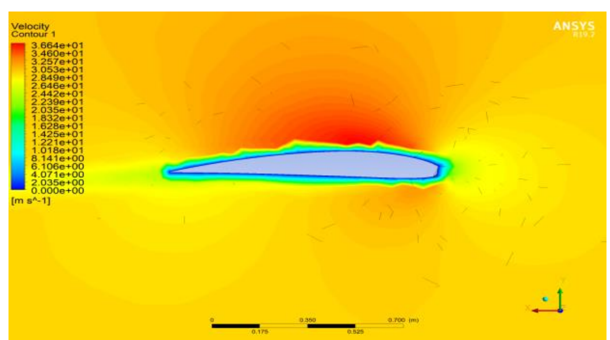


3D geometry of Morphing wing

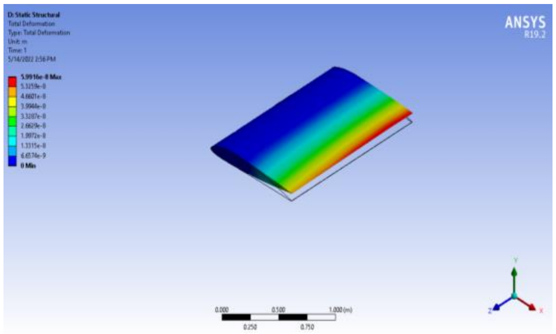
Unstructured mesh of trailing part model has been created for avoiding complexities and errors. Material applied is Aluminum alloy 2024 T4.



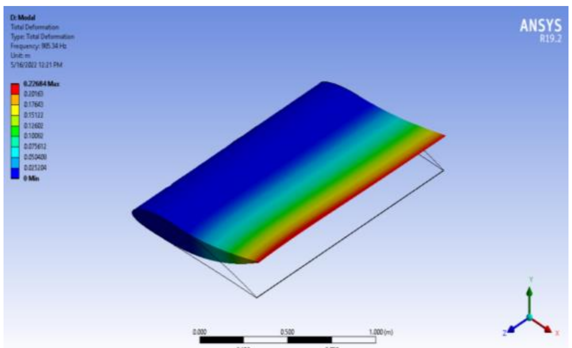
Applying Boundary conditions with velocity inlet (50m/s) and pressure outlet, 200 iterations are performed and here is the residual graph and velocity, pressure contours

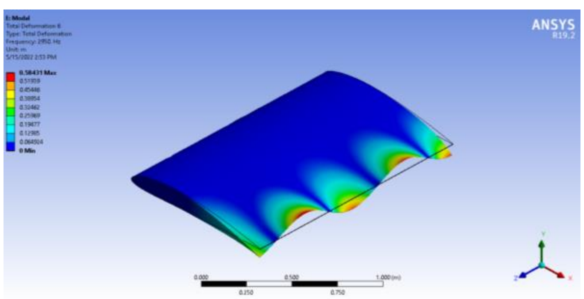


Velocity Contours



Total Deformation of Morphing wing

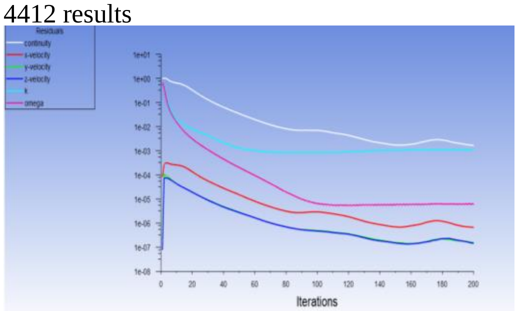


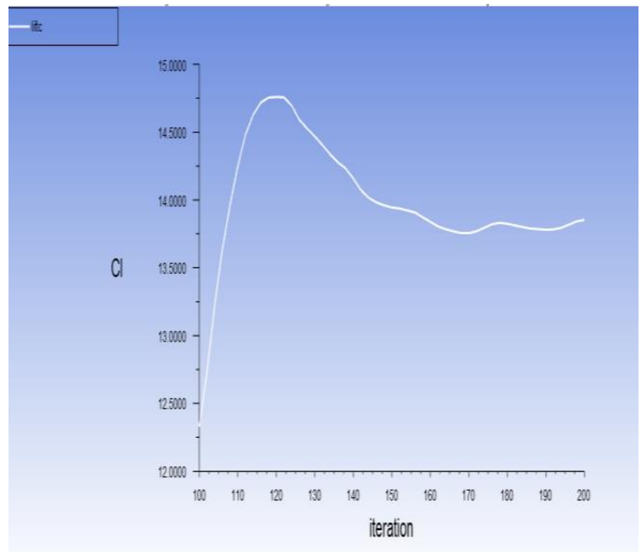


Modal analysis of Morphing Wing

Results

The model analysis and FSI analysis given the bes result more than we expected the above graph show s the morphed wins analysis of NACA 4412 results





Conclusion

The most of the work done by done may many reference papers are NACA 4412 that can give more flexibility to the light weight structures and can be given to high lift

One of the first things that needs to be done before construction of the wing is to calculate the sensitivity the final cost has for deviations of the nodal locations, member area, and joint stiffness and friction. The more sensitive the cost is to any deviation from the optimal design, the more exacting and difficult it will be to construct. Finally, the lift and drag should be assessed experimentally in a wind tunnel for the twisting wings.

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