AIRCRAFT WING MORPHING USING AUXETIC STRUCTURES

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Introduction:

This study investigates the in-plane flexible properties of cellular materials, focusing on designing a passive morphing airfoil with flexible cellular cores. It analyzes airfoils with re-entrant and S-shaped cellular cores under static loads to understand their deformation under aerostatic conditions. The research aims to enhance the flexibility and performance of airfoils using auxetic structures, which have a negative Poisson's ratio and high in-plane flexibility. 3D CAD models of re-entrant and S-shaped auxetic airframes were designed and analyzed through static structural analysis.

Objectives:

• To model an Eppler-420 airfoil with Re-Entrant Auxetic Structure and validate it with reference paper.

• To model an Eppler-420 airfoil that incorporates a S-shaped auxetic pattern.

• Performing Static Structural Analysis of both airfoils with auxetic structures to check the flexibility of the auxetic structure.

• Modelling of wings using the above 2 auxetic airfoil ribs.

• Performing CFD analysis of wing to obtain air-loads acting on the wing and importing the loads on wings for structural analysis of wings.

• Performing structural analysis on both wings to check the structural performance of the wings. Comparing the results obtained.

Methodology:

• Modelling of Eppler-420 airfoil with auxetic structure using SOLIDWORKS resulting in Re-entrant and S-shaped auxetic frame.

• Conducting static structural analysis on the two airfoils using ANSYS and comparing the results and plotting respective graphs.

• Performing CFD analysis on wings to obtain air-loads on the wings and the respective pressure contour.

• Conducting static structural analysis on both auxetic wing structures by importing air-loads and comparing the results.

Future Scope:

• The parametric study can be carried out based on different positions of auxetic patterns.

• To study the aerodynamic properties at different morphing angles.

• The accuracy of air-loads can be further improved by using finer mesh for CFD.

• Weight and structural strength can be improved and enhanced by using composite and other lightweight materials.

• Structural optimization can be carried out to improve the flexibility of the auxetic core.

Conclusion:

In this paper, we investigated the in-plane mechanical properties of auxetic airframes using re-entrant and S-shaped auxetic patterns and their application in passive morphing for its flexible cores. The morphing airfoil with an auxetic pattern was studied under static structural analysis and aero-static loads.

• The 3D model of the re-entrant Eppler-420 airfoil was designed and validated for static structural and CFD analysis.

• For the same applied force of 300N, the maximum equivalent stress of the Re Entrant airframe and S-shaped airframe was found to be 143.99MPa and 180.25MPa respectively. With a reduction in stress by 20%, the Re-entrant airframe exhibits lower stress and hence more flexibility.

• Considering the same design parameters and materials, both auxetic wings have also been modelled, taking a span of 1m.

• The CFD analysis was performed by taking inlet velocity as 154m/s as per base paper and CL and CD were obtained as 0.153 and 0.061 respectively. And air-loads acting on the wing were captured.

• The fluid-structure interaction was studied on auxetic wings with imported air-loads from CFD on the upper and lower surface of the wing, to observe the structure's behavior and performance.

• It was found that the Re-entrant auxetic wing showed an increase of 9.99% in load carrying capacity, accompanied by a decrease of 389 grams of weight when compared to the S-shaped auxetic wing. The mass of the re-entrant wing and S auxetic wing are 15.62Kg and 16.09Kg respectively.

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