ICCES, 2026, vol.36, no.1

Tech Science Press

DOI: 10.32604/icces.2026.013708

PROCEEDINGS

Modeling and Experimental Validation of Variable Camber Wing Structure Based on Zero Poisson's Ratio Lattice

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ABSTRACT

With the increasing demand for adaptive aerodynamic performance in aircraft, morphing wings have gradually become an important research direction in the aerospace field [1-3]. Among various morphing concepts, smooth and continuous variable camber wings (VCWs) can improve aerodynamic efficiency, reduce fuel consumption, and decrease noise during takeoff and landing. Therefore, achieving smooth and continuous camber variation has become one of the important development trends for future aircraft [4-6].

To realize smooth and continuous camber variation, this study proposes a variable camber wing structure (VCWS) based on a zero Poisson's ratio lattice structure. The zero Poisson's ratio lattice structure can maintain good shape stability during deformation and effectively avoid transverse coupling effects. When used as the morphing structure of the wing, it enables camber adjustment along the chordwise direction. In addition, an actuation system composed of a servo motor and an eccentric lever mechanism is designed to achieve controllable camber deformation.

First, based on the energy method and an iterative approach, a theoretical model is established to predict the tensile stiffness of the zero Poisson's ratio lattice structure. The prediction accuracy of the model is verified through tensile experiments and numerical simulations. Subsequently, based on the energy method and the tensile stiffness model of the lattice structure, a theoretical model is developed to predict the relationship between the driving torque and camber configuration variation of the VCWS. Numerical simulations are conducted to analyze the deformation process of the VCWS, and the relationship between the driving torque and structural configuration variation is obtained. Finally, based on the theoretical analysis and numerical simulation results, a prototype VCW is fabricated and ground functional tests are successfully carried out.

The results show that the proposed VCWS can achieve smooth and continuous camber variation with good structural stability. The predictions of the theoretical model agree well with the numerical simulation and experimental results, validating the effectiveness of the proposed theoretical model. This study provides an important theoretical basis for the design of VCWS based on zero Poisson's ratio lattice structures.

KEYWORDS

Morphing aircraft; variable camber wing; zero Poisson's ratio lattice structure; morphing structure

Acknowledgement: Funding from the National Natural Science Foundation of China is gratefully acknowledged.

Funding Statement: The work was supported by the National Natural Science Foundation of China (52275231).

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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