FLUID-STRUCTURE INTERACTION ANALYSIS OF A FOUR-BAR FLAPPING WING MECHANISM

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ABSTRACT

In this paper, it is introduced to find net aerodynamic lift capacity of proposed flapping-wing micro air vehicle (FWMAV) by performing dynamical calculation and FSI (Fluid Structure Interaction) analysis of a flapping wing test system. In the flapping system, a single degree of freedom type four-bar mechanism which was used as a piezo-driven flapping wing mechanism in previous literature studies is implemented to create beating motion of the wings [1]. For the wing structure, Calliphora Erythocephala's wing is used which is presented by Konkuk University [2]. The flapping wing mechanism and wing structure are fabricated by 1 mm of plexiglass. In FWMAV applications, in order to produce enough force to levitate the flapping structure, the inertial forces are created by flapping wing mechanism should not dominate on aerodynamic lift capacity of the wings. In this framework, the real-time flapping test is performed by six degrees of freedom force transducer for a specific flapping frequency (11.2 Hz) to understand inertial and aerodynamic characteristics of the proposed mechanism and test results are presented. The theoretical approach is put forward by obtaining the dynamic model of the proposed flapping structure. The initial angular position, mass, and radius of rotation values of the major linkages of the flapping wing mechanism are presented. Tangential and centrifugal forces acting on major linkages of the four-bar flapping wing mechanism are found and total inertial characteristics of the proposed mechanism are obtained in different axes. FSI analysis of the proposed flapping wing mechanism is performed to understand how the elasticity of the wing effects of the aerodynamic lift capacity of the structure. The aeroelastic analysis is modelled based on the conditions are performed in the test phase. The Fluid-structure interaction model is created in two different domain using ABAQUS CAE and STARCCM+. ABAQUS CAE is used to create the structural dynamics finite element model of the proposed flapping wing structure. A time-dependent dynamic implicit analysis step is created in finite element analysis (FEA) model and sinusoidal input is defined to the corresponding linkage and inertial results are shared. In this framework, the wing is modelled in STARCCM+ interface. The inertial force results belonging to FSI analysis is presented and compared with the theoretical model and experimental test results.

References

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