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3D Numerical Studies and Design Optimization of a Swallowtail Butterfly with Twin Tail

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Abstract : Aerodynamics of insects is of topical interest in aeronautical industries due to its wide applications on various types of Micro Air Vehicles (MAVs). Note that the MAVs are having smaller geometric dimensions operate at significantly lower speeds on the order of 10 m/s and their Reynolds numbers range is approximately 1,50,000 or lower. In this paper, numerical study has been carried out to capture the flow physics of a biological inspired Swallowtail Butterfly with fixed wing having twin tail at a flight speed of 10 m/s. Comprehensive numerical simulations have been carried out on swallow butterfly with twin tail flying at a speed of 10 m/s with uniform upper and lower angles of attack in both lateral and longitudinal position for identifying the best wing orientation with better aerodynamic efficiency. Grid system in the computational domain is selected after a detailed grid refinement exercises. Parametric analytical studies have been carried out with different lateral and longitudinal angles of attack for finding the better aerodynamic efficiency at the same flight speed. The results reveal that lift coefficient significantly increases with marginal changes in the longitudinal angle and vice versa. But in the case of drag coefficient the conventional changes have been noticed, viz., drag increases at high longitudinal angles. We observed that the change of twin tail section has a significant impact on the formation of vortices and aerodynamic efficiency of the MAV's. We concluded that for every lateral angle there is an exact longitudinal orientation for the existence of an aerodynamically efficient flying condition of any MAV. This numerical study is a pointer towards for the design optimization of Twin tail MAVs with flapping wings.

Keywords : aerodynamics of insects, MAV, swallowtail butterfly, twin tail MAV design
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