Numerical and experimental investigation of dynamic behavior of square section missile in roll at high incidence

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Abstract: A method to predict the rolling characteristics of square section missile at high angle of attack using an unsteady RANS solver is presented. The static and dynamic derivatives of rolling moment were obtained by forced roll motions. The free-to-roll behaviors for different incidence were conducted by implicitly sub-iterative solving the coupling equations of the fluid dynamics equations and 1 degree-of-freedom (DOF) flight mechanics equations synchronously in order to predict the onset and the development of uncommented motions and then explore the unsteady movement characteristics of the missile. Based on the two results mentioned above, it was found that the rolling motions of square section missile translated from stability to instability, i.e. damping oscillations, and then formed limit-cycle rock motion when incidence was increased, then coming into rolling divergence when incidence was kept up. Predicted results based on CFD showed good agreement with the available wind tunnel data. The mechanism of rock motions were explored too. The study indicated that the missile loss stability in high angle of incidence was caused by the asymmetric vertex on the level fin tip liftoff and attach alternately.

Key words: square section missile; stability; unsteady flow; coupling sub-iterative; limit-cycle; damping derivatives