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VARIABLE CALCULATION DOMAIN AERODYNAMIC NUMERICAL METHOD FOR SPACECRAFT DEBRIS REENTRY DISINTEGRATION

Abstract

When the spacecraft reenters to the continuous flow area, the energy flow generated by high temperature and high speed causes the ablation explosion of the re-entry module, involving the large space disintegration of spacecraft. In order to simulate the spacecraft debris motion trajectory over a wide, long distance and long time in the interference region of reentry disintegration, a aerodynamic numerical method based on dynamic boundary conditions was developed, whose computing domain changes with the debris. The main difficulties in long distance and long time separation of spacecraft are as follows: (1) High Mach number multi-body separation motion; (2) The separation interference area is wide, causing the required calculation domain is large, and the efficiency and precision are hard to reconcile. This study focuses on the following specific problems: (1) Experimental research on numerical simulation of multi-body separation in large space using variable computing domain method is carried out; (2) Large space analysis of the interaction of different shapes of debris after disintegration; (3) Study on the accuracy of variable calculation domain method, and study on the continuity of spacecraft debris trajectory simulation data; (4) To expand the computational domain by combining the dynamic boundary conditions with the variable computational domain, and to solve the problem of free debris' falling area prediction. In this study, the numerical mesh was generated by the reconstruction of a three-dimensional unstructured viscous rectangular mesh. The ALE-6DOF coupling system is decoupled by loose coupling method, and the prediction - correction step or multi-step iteration is introduced to improve the calculation accuracy. The finite volume discretization method of ALE governing equation based on lattice center and double time step method are used for space discretization and time discretization. Based on the above calculation method, a set of system is formed which can be used to solve the problems of reentry, disintegration, long distance and long time fragmentation of spacecraft, and its feasibility is verified by the analysis of the above four kinds of specific problems. The research results aim to provide an accurate and efficient numerical simulation method for spacecraft reentry, disintegration and multiple separation problems, and lay a foundation for the subsequent trajectory prediction and optimization of the long time, long distance and large space fall of the separated parts. Key words: reentry debris, large space, variable calculation domain, numerical computation