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Hypersonic Air-breathing and Combined Cycle Propulsion (9)

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PROGRESS ON COMPUTATIONAL DISINTEGRATION AND SEPARATION PROCESS FOR HYPERSONIC VEHICLE

Abstract

Hypersonic vehicle propelled by hypersonic air-breathing propulsion or combined cycle propulsion has been caught much attention with the motivation of reducing the cost of space access and space transportation as well as space exploration. However, it is still very challenging to develop such kind of hypersonic vehicle. One of the challenging technical problems is that during the process of reentry into the atmosphere, the vehicle may be disintegrated and, as result of this, separated due to the harsh environment caused by combined effects of gravity force, aerodynamic force, space magnetic force, the solar radiation heating and aerodynamic heating. The disintegration and separation process during high speed reentry is a series of complex dynamic procedures that involve complex shape multi-body movement, complex flow phenomena, and complex aerodynamic interactions. The structure disintegration and separation process of the vehicle have huge effects on its aerodynamic shape and flight attitude, which largely determines the ultimate flight trajectory and impact locations of the disintegrated components. In this paper, the progress of disintegration and separation process for hypersonic vehicle by means of CFD is presented. The factors considered in the research include: 1) Complex shape multi-body dynamic mesh generation; 2) Unsteady flow simulation of multi-body movement; 3) Computation domain handling for large altitude range and large movement displacement; 4) Simulation of components separation under direct force; 5) Simulation of rigid body collision; 6) Fast and high efficient parallel computation of the disintegration and separation process; 7) Large altitude range components trajectory and impact location computation.

Based on the above factors considered, studies have been conducted on the following areas: 1) Multi-body dynamic mesh rebuilds and elastic mesh generation; 2) Unsteady flow simulation of multi-body movement; 3) Layering numerical simulation for large altitude range; 4) Numerical simulation of interactions between components during disintegration and separation; 5) Distributed storage (such as MPI) and shared storage (such as OpenMP) parallel computation for the disintegration and separation process; 6) Components trajectory and impact location computation.

Numerical simulation theory and method for complex shape multi-body movement in complex flow have been developed. The layering numerical simulation concept is set up for large altitude range simulation.

The established numerical method not only can be used to investigate the disintegration and separation process, but also can be used to study the complex process of stage separation, cowl separation and release separation, etc. Finally, envision of further studies on these research areas is proposed.