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NUMERICAL RESEARCH ON THE SEPARATION PROCESS OF LAUNCH VEHICLE'S BOOSTERS WITH THE IMPINGEMENT OF MULTIPLE NOZZLE PLUMES OF ITS CORE STAGE

Abstract

For launch vehicles, the boosters' attitudes will be influenced by multiple nozzle plumes when separating, if the core stage's engines are power-on. The change of the attitudes may influence the safety of the booster's separation process, as well as their trajectories after separation. Besides the multiple nozzle plumes, external airflow must be considered as well. Due to the complicated separation environment and process, ground experiments are difficult to conduct. Therefore, numerical simulation method is adopted here for analysis. An approach based on hybrid dynamic mesh is proposed, with which aerodynamic external flow and multiple nozzle plumes can be taken into account. The hybrid mesh constitutes of structured mesh in boundary zones and unstructured mesh in other zones, which can predict more accurate aerodynamic forces than all unstructured mesh and be more convenient for simulations of moving parts than all structured mesh. Time accurate Navier-Stokes simulations of full flow field coupled with rigid dynamics of boosters were carried out. The full flow field is formed by supersonic external airflow coupled with multiple nozzles' flow, and two-species gas model and Spalart-Allmaras turbulent model are adopted. The results of these simulations are compared to the analyses which didn't consider the effect of multiple nozzle flows. The displacement of center of gravity and velocity of the each booster are enlarged, but turn-over angle and angular velocity are reduced. At the same time, the booster also has displacement in side direction due to the asymmetry installation of the core stage's engines. The detailed pressure distributions of the booster's surface are also given during the separation process. The results show that, the method introduced here can predict the attitudes of the boosters more accurately, as well as providing more detailed load information for further strength analyses.