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C1Po1B-03 [12]: Investigation on thermodynamic characteristics of cryogenic propellant slosh under varied gravity conditions

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Acceleration variation in low-gravity environment could significantly affect propellant slosh as well as thermodynamic behaviors inside cryogenic tank of vehicle upper stage. To realize reliable space management of cryogenic propellant, liquid-gas interface movement and deformation as well as associated pressure evolution during the slosh process should be understood previously. In the present study, a 3-D computational fluid dynamics (CFD) model based on FLUENT software is introduced to assist the slosh analysis. The interface variations under different gravity changes are simulated, and interface oscillation damping features for both of smooth tank and baffle tank are compared and presented. The results show that the baffles indeed suppress interface slosh amplitude under relatively high gravity level, while the baffles effect is reduced under low-gravity condition. Moreover, when liquid level is higher than the top baffle position, the baffles could not suppress the slosh apparently. If the propellant tank experiences a sudden change from a high gravity to the microgravity level, extra contact between cold liquid and hot ullage-adjacent wall could bring about remarkable heat transfer and liquid evaporation, which further suppress the depressurization behavior in the beginning of ballistic period. In general, the present study could present the fluid behaviors and thermodynamic characteristics inside the cryogenic tank under slosh conditions, and the results could provide a reference for space propellant management and sequence setup.

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