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Evolution of Stratification and Self-Pressurization of Liquid Nitrogen for JT Cryocooler under Elevated Gravity Condition

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The prediction of thermal stratification in a cryogenic storage tank is necessary for the successful execution of the prolonged working of a J-T cryocooler in space-related applications. The working fluid may be stored in the subcooled conditions, and the possibility of heat infiltration may lead to an increase of temperature as well as the pressure of the cryogenic fluid. Commonly used stratification models are based on temperature and velocity correlation developed for flow over a flat plate. The evolution of stratification during lift-off and accelerated conditions will be different from that during normal ambient conditions. During lift-off, the gravity value can reach up to 6g. So modeling of stratification in the cryogenic tank is essential to determine the state of cryogen during a space mission. A multiphase axisymmetric computational model is developed, which can simultaneously account for the heat exchanges within the storage tank and also heat transfer from the ambient condition during lift-off. VOF method is used and heat and mass transfer models are also incorporated to study the effect of phase change on thermal stratification. The model is validated with the experiments conducted at cryogenic test facility at CASC lab.The results show that the temperature of bulk fluid temperature will be higher during lift-off and accelerated state, and reduction in the rate of pressure rise after lift-off was noted, which was due to turbulence created by the liquid. Since the geometry used is a perfect cylinder, further studies about stratification are required by considering actual tank geometries.