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Effect of bottom heating on thermal stratification and self-pressurization in a cryogenic tank

Content :

The aerodynamic side wall heating is an inevitable phenomenon happening in a cryogenic propellant tank during a space mission. The side wall heating leads to thermal stratification and self-pressurization of propellant tank. The rise in propellant temperature may also leads to cavitation in pump which has to be avoided. So modeling of stratification in cryogenic tank is essential as the liquid propellant must meet the pump inlet condition. Self-pressurization in a cylindrical tank which is partially filled with liquid hydrogen is investigated numerically under constant side wall heating and varying bottom heating. The Volume of Fluid (VOF) method is employed as well as a phase change model. The model is validated with experimental data reported in the literature. Numerical results indicate that considerable amount of side wall heating goes into raising the temperature of the fluid inside the boundary layer which enhances the stratification. By providing controlled bottom heating, some agitation is introduced, which disturbs the formation of free convection boundary layer. Due to the absence of well-defined free convection boundary layer flow in the tank, most of the side wall heating goes into raising the temperature of the bulk liquid, resulting delayed stratification.

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