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PROCEEDINGS

Numerical Study on the Sloshing and Thermodynamic Characteristics of Liquid Hydrogen Storage Tank in Hydrogen-Powered Aircraft

Zhibo Chen[1], Jingfa Li[1,*], Bo Yu[1], Jianli Li[1] and Wei Zhang[2]

[1]School of Mechanical Engineering, Beijing Institute of Petrochemical Technology, Beijing, 102617, China
[2]Fujian Boiler and Pressure Vessel Inspection Institute, Fuzhou, 350008, China
[*]Corresponding Author: Jingfa Li. Email: lijingfa@bipt.edu.cn

ABSTRACT

Using liquid hydrogen as fuel is helpful to the aviation industry to achieve the goal of carbon peak and carbon neutrality. However, the liquid hydrogen storage tank will inevitably slosh during the use in hydrogen-powered aircraft, thus it is necessary to study the thermodynamic characteristics of liquid hydrogen storage tank during the sloshing process. In this paper, the thermodynamic behavior of liquid hydrogen storage tank under external excitation is studied by using Volume of Fluid (VOF) model and Lee model through numerical simulation methods. The changes of pressure and temperature in the process of tank sloshing under external excitation, the characteristics of wall force as well as vapor and liquid phase interface fluctuation are analyzed, and the influence of baffle installation on above characteristics is also explored. The results show that: (1) The vapor is cooled by the liquid hydrogen and produces a condensing phase transition, which leads to the reduction of tank pressure. The baffle plate has a certain inhibition effect on the pressure drop in the tank sloshing process. The installation of baffle plate can reduce the rate and amplitude of tank pressure drop compared with the uninstallation of baffle plate. (2) In the sloshing process, with the heat leakage from the tank and the convection heat transfer between the vapor and liquid phase inside the tank, the temperature in the liquid phase zone inside the tank gradually increases, while the temperature of gas hydrogen in the vapor phase zone gradually decreases due to the influence of liquid hydrogen. The installation of baffles can reduce the temperature variation range in the vapor and liquid regions. (3) The baffle plate has obvious inhibition effect on the interface fluctuation elevation during tank sloshing. When the baffle plate is uninstalled, the interface fluctuation elevation is large and violent. After the baffle plate is installed, the interface fluctuation elevation is significantly smaller and relatively stable. (4) The baffle plate can significantly weaken the sloshing force on the wall of the liquid hydrogen tank. Compared with the uninstallation of the baffle plate, the sloshing force on the tank wall after the installation of baffle plate is greatly reduced and relatively stable, while the overall sloshing force on the tank wall is larger and unstable when the baffle plane is not used. This study can help to understand the thermodynamic characteristics of the liquid hydrogen in the sloshing process under external excitation in hydrogen-powered aircraft.

KEYWORDS

Liquid hydrogen tank; hydrogen-powered aircraft; sloshing; thermodynamic characteristics; numerical simulation

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