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PROCEEDINGS

Optimization of Thermal Management Structure of Multilayer Concentric Circle Metal Hydride - Phase Change Material Reactor

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ABSTRACT

Metal Hydride (MH) is a promising hydrogen storage technique owing to its safety, availability, and high volumetric storage density. MH hydrogen storage reactor is the core component of MH hydrogen storage technology. However, the thermal effect of MH hydrogen storage reactor in the process of hydrogenation/dehydrogenation is significant, which requires an efficient heat management system for the reactor. Phase change materials (PCM) can be applied to MH hydrogen storage reactor, and have the advantages of simple structure. In this paper, representative PCM thermal management methods were summarized, and the distribution structure of the existing multi-layer MH-PCM reactor was investigated and optimized numerically. A transient two-dimensional axisymmetric numerical model of $LaNi_5$ metal hydride storage layer was established by using COMSOL Multiphysics software, and a transient two-dimensional axisymmetric numerical model of MH-PCM reactor composed of $LaNi_5$ and commercial paraffin RT35 was established and simulated. The simulation results showed that, for a radially arranged MH layer, a ring-shaped center layer is preferable to a cylindrical one, and a uniform distribution of PCM thickness is not an optimal distribution method, while a reactor with same MH and PCM layer heights has better hydrogen absorption performance than that with lower MH layer height. After the better structure is selected, the thickness distribution of PCM layer is further studied, and the following conclusions were obtained: (1) The total latent heat and thermal resistance of PCM are two factors that affect the optimal distribution scheme of PCM layer, which are manifested as the total mass and thermal conductivity of PCM in MH-PCM system affecting the optimal distribution scheme of PCM layer. (2) Under different PCM amounts or different PCM thermal conductivities, the optimal thickness ratio of PCM layer for its absorption time ($t_{90\%}$), based on 90 % absorption, and its absorption time ($t_{100\%}$), based on 100 % absorption, can be expressed as X:8:8:8:4, which means that only the thickness proportion of the first layer of PCM is unknown. (3) Compared with the case of a single-layer PCM jacket structure, with the change of PCM arrangement mode, the $t_{90\%}$ is reduced by 98%, and the optimal thickness ratio of PCM layer was 40:8:8:8:4; The $t_{100\%}$ is reduced by 96%, and the optimal thickness ratio of PCM layer was 18:8:8:8:4.

KEYWORDS

Hydrogen storage; metal hydride; phase change material; heat transfer; reactor; numerical simulation

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