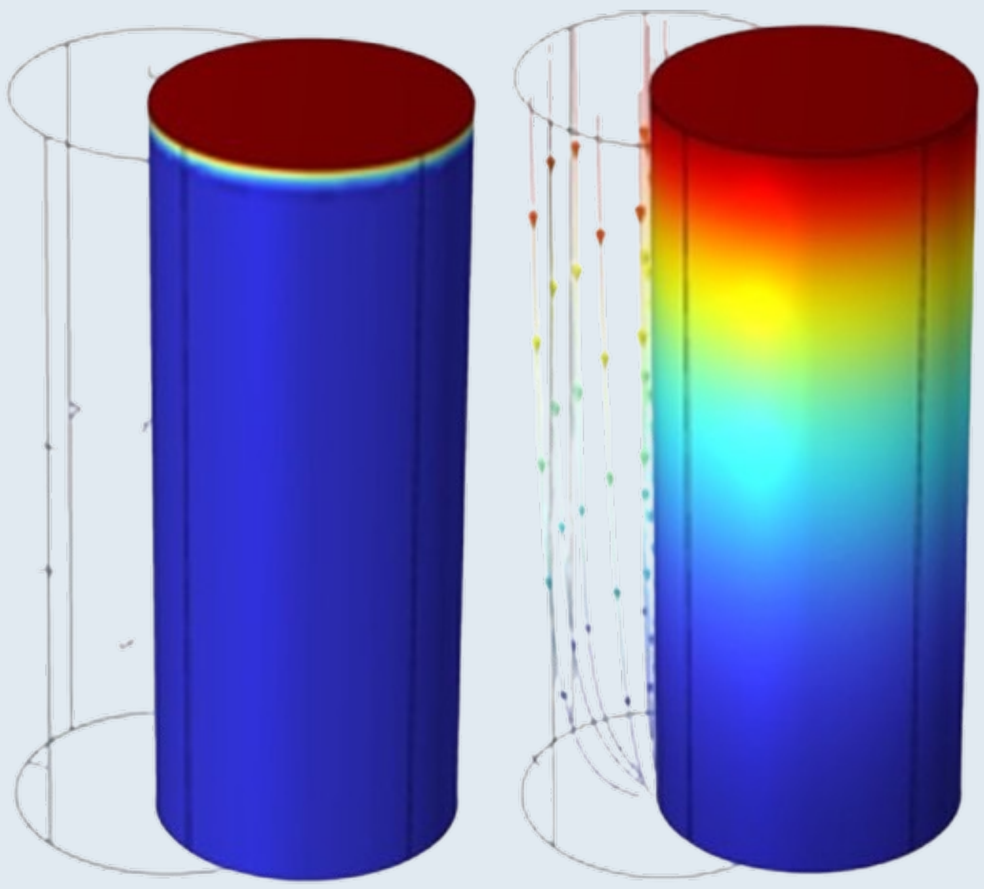

Numerical Investigation of Parameters Influencing the Thermal Behavior of Solide State Hydrogen Storage Tank

Understand the effects of the various parameters influencing the thermal behavior of a solid hydrogen storage tank.

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Abstract

Effectively storing hydrogen in solid form using metal hydrides requires careful attention to thermal management challenges due to the exothermic nature of hydrogen absorption in metal hydrides (Ref.1). The generated heat during this process must be efficiently removed to achieve optimal performance of the storage system (Ref.2). In this work, a 3D model of a metal hydride LaNi5-based solid hydrogen storage tank is developed utilizing the COMSOL Multiphysics® software.

The main objective of this study is to understand the effects of the various parameters influencing the thermal behavior of the tank. To determine the parameters for optimizing fast and efficient heat exchange, the study investigated the impacts of supply pressure and heat exchange coefficient. The simulations results show the need to take these parameters into account when designing a hydride tank.

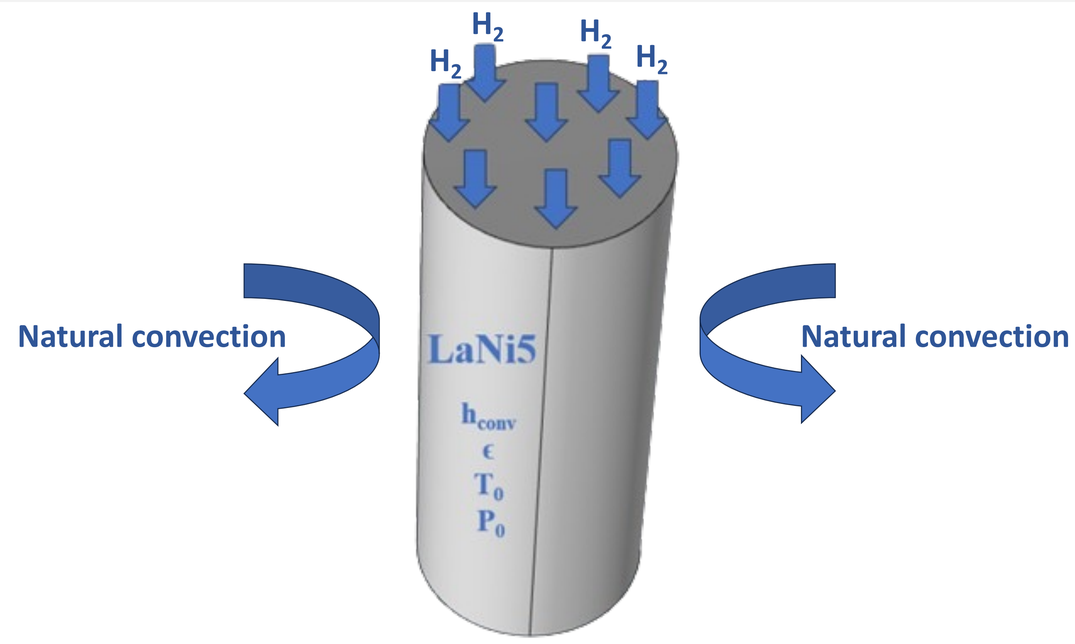

FIGURE 1. 3D schematic of the model geometry

Methodology

A solid hydrogen storage tank based on metal hydride LaNi5 was modeled. The tank has a cylindrical shape with a radius of 0.25 m and a height of 1 m. The hydrogen is injected into the tank from the top. The lateral surface experiences cooling through natural convection, while the remaining orthogonal surfaces are presumed to be adiabatic behavior (Figure 1).

To simulate the temperature distribution within the tank, the model incorporates the coupling of momentum, heat, mass, and energy transfer within the LaNi5 metal hydride during hydrogen absorption. Based on this tank model, this study aims to understand the effects of the various parameters influencing the thermal behavior of the tank.

Results

As illustrated in Figure 2, a detailed study of the temporal evolution of the temperature in of a solid hydrogen storage tank based on metal hydride LaNi5 technology was conducted by varying the hydrogen supply pressure (P_{H_2}) and the nature of the wall (h_{conv}).

The parametric study demonstrated that the hydride temperature converges more rapidly towards ambient temperature as the hydrogen supply pressure and heat exchange coefficient increase. This observation highlights the significant influence of these parameters during absorption simulations. The results indicate the necessity of accounting for these parameters when designing a hydride tank.

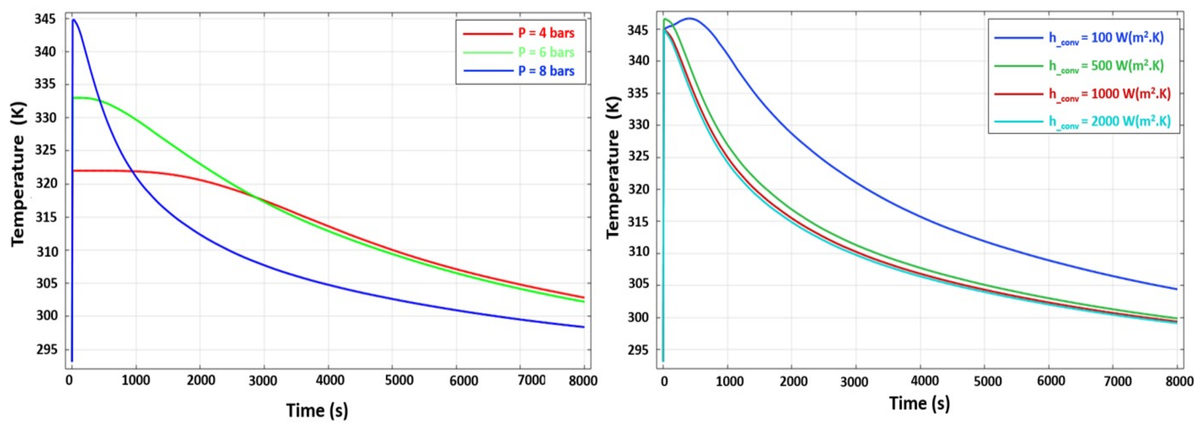

FIGURE 2. Left: User Interface for the Electromagnetic Thermal Management Model of PMSM. Right and center: 2D Temperature distribution with forced air convection and forced water cooling respectively

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