Thermal Integration of Coupled SOFC System with a High-Performing Metal Hydride Storage

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Abstract

Auxiliary Power Units (APU) can play an important role in reducing vehicle emissions, especially in diesel and kerosene driven vehicles (road transport, building site machines, aircraft, ships etc.). In conventional vehicles the electricity supply comes from a generator that is directly coupled to the propulsion engine. New generation of fuel cell APUs exclusively use Solid Oxide Fuel Cells (SOFC) with some developments in high temperature polymer electrolyte membranes gradually emerging. [1]

In many fuel cell applications metal hydride tanks offer an interesting method of storing hydrogen as an alternative to compressed or liquefied hydrogen. Coupling this type of storage with a high temperature fuel cell, though, offers an opportunity of accessing the high storage capacity through the use of the off-heat of the fuel cell and at the same time exploiting the high conversion efficiency of the SOFC system of around 60% net.

COMSOL Multiphysics® was used to create 2D and 3D models to study the coupling of a Solid Oxide Fuel Cell and high temperature metal hydride storage supplemented with auxiliary hydrogen tank. This enables complete understanding of the systems behavior as well as optimizing the system by using different parameters in the simulation process during the warming up and operation process and aids in the design of the metal hydride tank & auxiliary hydrogen tank. Thermal integration of the metal hydride tank with a SOFC system should allow the recovery of heat needed for hydrogen desorption and can be can be considered in the market of Auxiliary Power Units (APU) for trains and trucks.

Results have shown the flow distribution of hot air through the air channels and whole stack which cause laminar flow in air channels (see figure 1) and also temperature variations of dry air and metal plates in the fuel cell stack with respect to time is another result of this simulation and it shows that, after 90 minutes (5400sec), the metal plate elements reach the required temperature of 800°C and the stack can start to produce heat and electricity. (see figure 2)

To increase the rate of heat transfer in metal hydride tank, the magnitude velocity of entering hot air in metal hydride tank is modeled and the result is symmetry around each pipe and whole tank. (see figure 3)

In this study, the coupling of a solid oxide fuel cell and metal hydride storage supplemented with

auxiliary hydrogen is modeled and simulated in order to have a complete understanding of the system's behavior as well as optimizing the system by using different parameters in the simulation process. Combining hydrogen tanks made from this material with an SOFC system in an APU application allows to use the high-quality off-heat of the SOFC for supplying the desorption heat for the tank.

Reference

1. Betty Y.S. Lina, Donald W. Kirkb and Steven J. Thorpea Performance of alkaline fuel cells Journal of Power Sources 161 (2006) 474-483

Figures used in the abstract

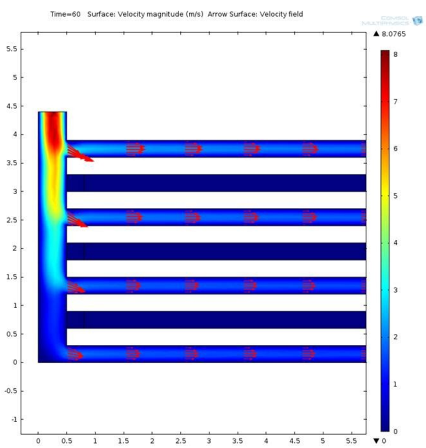

Figure 1: Flow direction of Hot Air in Air Channels

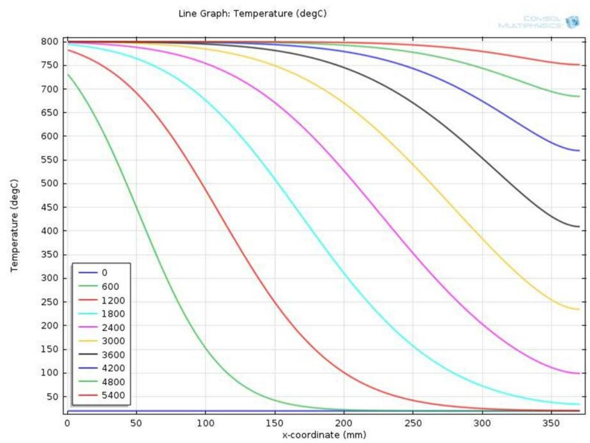

Figure 2: Temperature Variation of Stack in different times

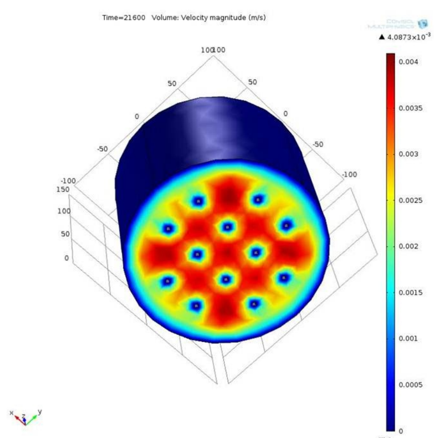

Figure 3: volume velocity magnitude of Metal Hydride tank