Tank designs for combined high pressure gas and solid state hydrogen storage - DTU Orbit (09/11/2017)

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Many challenges have still to be overcome in order to establish a solid ground for significant market penetration of fuel cell hydrogen vehicles. The development of an effective solution for on-board hydrogen storage is one of the main technical tasks that need to be tackled.

The present thesis deals with the development of a simulation tool to design and compare different vehicular storage options with respect to targets based upon storage and fueling efficiencies. The set targets represent performance improvements with regard to the state-of-the-art technology and are separately defined for each storage solution investigated in this work. Attention is given to solutions that involve high-pressure solid-state and gas hydrogen storage with an integrated passive cooling system. A set of libraries is implemented in the modeling platform to select among different material compositions, kinetic equations, heat exchanger configurations and to enable the tailoring of the analysis according to the user needs.

Reliable computational models are developed to describe hydriding and dehydriding reactions as well as melting and solidification processes that occur in the metal hydride tank and novel compressed-hydrogen vessel respectively. For the former, these models are used to quantify the main design parameter, being the critical metal hydride thickness, for the tank/heat-exchanger system.

For the metal hydride tank, the tubular layout in a shell and tube configuration with 2 mm inner diameter tubes is found to achieve the desired refueling time of 3 min and store a maximum of 3.1 kg of hydrogen in a 126 L tank. The dehydriding ability of this solution is proven to withstand intense discharging conditions.

For the hydrogen gas tank, a novel design that includes a phase change material in its inner volume. Heat transfer augmentation techniques (e.g. encapsulation) are found to be the reward strategy to achieve the same stored mass and fueling time of the standard technology, while enabling ambient temperature fueling and save the energy cooling demand (4.2 MJ per fueling) at the refueling station.

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