Compact Integrated Microchannel Combustor, Recuperator and Heat Exchanger (µCHX) For Hydrogen Storage Applications

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Abstract

A novel microscale combustor-heat exchanger (µCHX) for hydrogen storage applications is presented. The design of the µCHX is motivated by its application to two particular systems for automotive use- those that utilize metal hydrides (MH) and cryo-adsorbents (CA) to store hydrogen. In these systems, thermal energy needs to be provided to discharge and/or condition the hydrogen stream temperature prior to the fuel cell. This energy rate can be provided by combusting a small amount of hydrogen and transferring the heat from combustion to the working fluid, which is an oil in a MH system and hydrogen in a CA system.

The performance of the µCHX is documented using validated CFD simulations for variations in geometric and fluidic parameters. Parametric variations are captured non-dimensionally as variations in Damköhler and Peclet numbers. In the CA µCHX, extinction of the reaction due to the cold hydrogen stream is prevented using a novel distributed catalyst arrangement. Hydrogen conversion in excess of 99 percent is achieved for a range of operating conditions. A multi-watt CA µCHX is experimental characterized using nitrogen as a surrogate heat exchange fluid. Experimental results show that hydrogen residence time and body temperature has significant effects on the overall efficiency of the device. Conversions as high as 99.2% and efficiencies as high as 92.4% were achieved. Highest hydrogen conversion was achieved at equivalence ratio of 0.6.

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