INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: **Design and Testing of Metal Hydride Reactors for Stationary Hydrogen Storage and Cooling Applications**

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SHORT ABSTRACT

Metal hydrides (MH) are class of materials that offer compact, safe and ultra-pure hydrogen storage for longer periods. Also, by virtue of exothermic formation and endothermic dissociation, a wide variety of thermal devices can be engineered utilizing the MH-H_2 pair. However, the design of efficient MH reactors/heat exchangers is the most critical issue limiting hydrogen charging/discharging rate and therefore the concomitant heating/cooling effect.

In this work, a number of lab-scale (3-5 kg) as well as large-scale (25-30 kg) MH reactors have been conceptualized, devised and tested for hydrogen storage as well cooling applications. The design and optimization of the MH reactors are supported by numerical projections. The storage experiments confirmed that the designed MH reactors could feed 3-4 kW LT-PEMFC for 1-1.5 hours, needing only 0.5-0.7 kW heat input. The hydrogen discharge of the designed reactors was at least 31% faster compared to already reported MH reactors of both higher and lower capacities, subjected to similar operating conditions. Also, in a first, an open-cycle compressor operated MH based cooling system was proposed in this work. When assisted by a compressor, the open cycle cooling system exhibited 19% (MH: $La_{0.7}Ce_{0.1}Ca_{0.3}Ni_5$) and 51% (MH: $La_{0.8}Ce_{0.2}Ni_5$) improvement in specific cooling power ($W.kg^{-1}$) compared to the cooling system without a compressor. For closed cycle compressor operated cooling system, the maximum cooling power attained at 20 °C refrigeration temperature and 30 °C sink temperature was 1.44 kW, generating 537.3 kJ cooling effect within 600 s.

In the numerical part of the thesis work, two different numerical models were developed and applied to predict the hydrogen storage performance of the tested MH reactors and coupled bed cooling performance individually. The tube bundle reactor was projected to provide constant mass flow to 1 kW and 2 kW PEMFCs for a maximum duration of 5350 s and 2400 s, respectively at 70 °C. In the developed lumped model for compressor-driven cooling system, the effect of the compressor effect was taken care of by invoking suitable flow and pressure conditions without assuming a specific compression process. A comparison between variable flow and constant flow between the reactors through the compressor showed the assumption of a constant compression rate model slightly underestimates the compressor power consumption.