Preheating fuel cells at -20°C with metal hydrides using the pressure difference between tank and stack

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Fuel cells in vehicles have to be preheated in winter in order to expand service time and prevent ice formation. Metal hydrides can be used as solution to this challenge, as they can transform the pressure difference between hydrogen tank and fuel cell into heat. Until now, this potential energy stored in the high pressure hydrogen is throttled and lost. The working principle of a metal hydride pre-heater is the following: absorption of hydrogen at higher pressure into a metal hydride produces heat even at low ambient temperatures to preheat the fuel cell. Then, the lower pressure level of the fuel cell as well as waste heat enable desorption of the hydrogen from the metal hydride and the conversion in the fuel cell into electricity.

At our institute a reactor designed to investigate the preheating application for fuel cell vehicles was developed. $LaNi_{4.85}Al_{0.15}$ was used as heat producing material inside a tube bundle heat exchanger to reach high thermal power. Vehicle temperature conditions were simulated via a thermostatic bath considering a thermal regeneration at 130°C against ambient pressure. Hydrogen was provided to the material in a temperature range between -20 and 20°C and a pressure range between 1 and 10 bar, and the thermal power transferred into the heat transfer fluid was measured.

The study could verify high thermal power of metal hydrides at low ambient temperature suitable for automotive applications. The experiments showed that the 960 g of material could transfer a thermal power of up to 5 kW_{peak} at -20°C into the heat transfer fluid. Different influence factors on the thermal power were investigated, such as ambient temperature, hydrogen pressure and mass flow rate of the heat transfer fluid. The biggest influence on the thermal power showed the hydrogen pressure as can be seen in Figure 1.

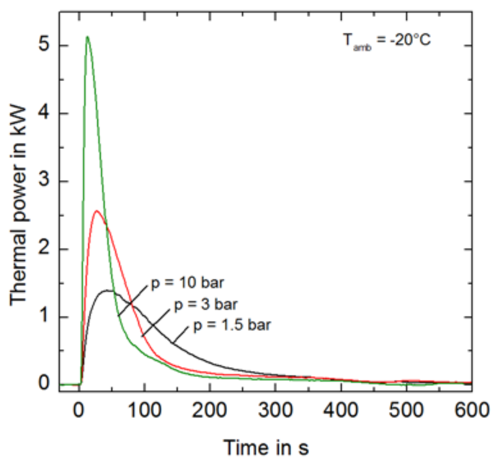

Figure 1. Thermal power measured in heat transfer fluid at ambient temperature of -20°C.