

Influence of heat transfer in metal hydride beds on efficiency of hydrogen storage systems

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Hydrogen storage in solid state is useful for various practical applications. Metal hydride systems are safe, because hydrogen is bounded in solid storage material and operating temperatures and pressures are close to normal conditions; compact – hydrogen density is higher than in liquid state and highly effective due to ability to use waste heat and renewable energy and low cost of long term storage. Also, selectivity of hydrogen sorption can be used to purification of hydrogen on site.

Development of high efficient fuel cells coupled with solid state hydrogen storage and purification will solve the problem of autonomous and uninterrupted power supply on the level up to 20 kW of such consumers as telecommunication equipment, medical facilities, data centers, etc.

In contrast to mobile applications for stationary systems the hydrogen capacity of storage materials is not the primary necessity. Optimal operational properties assuring increase of overall efficiency and better integration with fuel cells are more important. Higher efficiency requires reducing of energy losses, thus the system has to work at temperatures lower than 100°C and use waste heat from fuel cell. AB5 metal hydrides appear to be the best choice for new due to low operating temperatures, high flexibility and tolerance to impurities. Hydrogen purification inside the fuel supply system can significantly lower operating costs due to usage of low quality hydrogen and also increase life time of power unit.

In activated form hydrogen storage are the fine powders with particle sizes down to 1–10 mkm with relatively low effective thermal conductivity (0.1–1 W/m·K) and high reaction heat (25–70 kJ/mol H₂). As the result heat management is the bottleneck of design of efficient metal hydride systems. Our experiments show that heat transfer coefficient from AB5-type alloy to cooling water is only about 120 W/m²K and determined mostly by heat transfer in metal hydride bed practically independent from coolant flow regimes.

Comparative tests of several metal hydride reactors were made:

- PXO-1 – the reactor consists of O-ring shaped capsules filled with MH bed, the capsules are assembled in cylindrical casing with water heat exchanger at outer wall;
- PXO-2 – the reactor consists of several tubular cartridges, each cartridge consists of coaxial tubes with metal hydride bed between them, coolant flows through inner tube and along outer surface;
- PXO-5 – experimental cartridge with inner cooling tube and corrugated outer wall for better heat transfer.

Results of tests are presented in Fig. 1. Optimized design of PXO-2 and PXO-5 reactors helped to highly increase hydrogen charging rate. These reactors can be used in newly developed hydrogen storage and purification systems.

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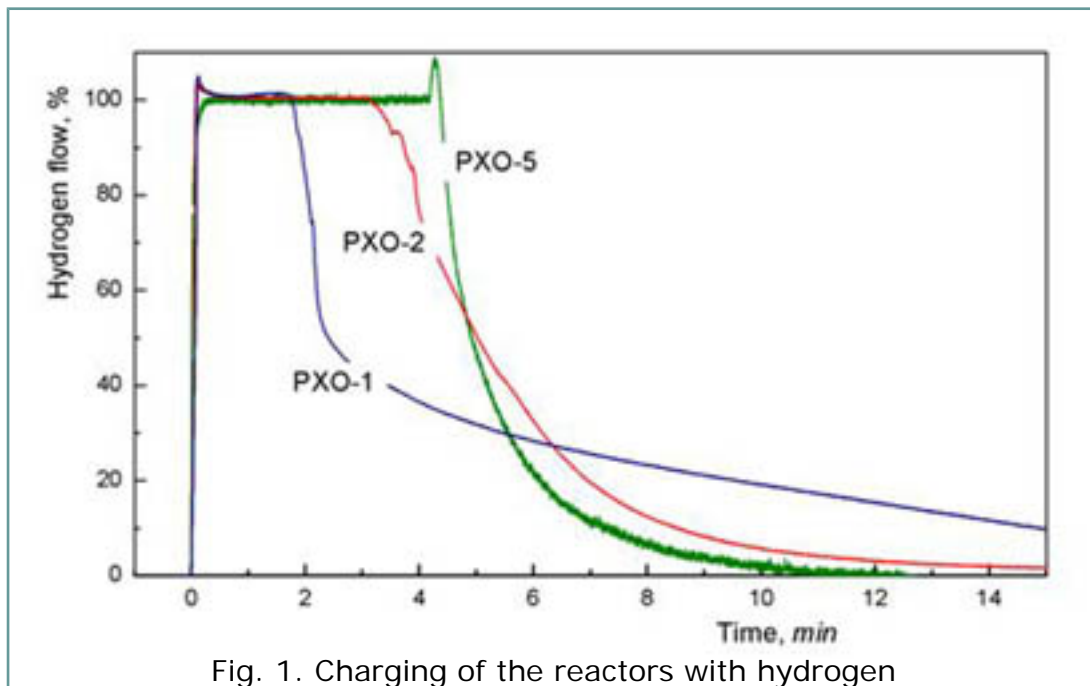


Fig. 1. Charging of the reactors with hydrogen