Optimization of PEM water electrolysers

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Today water electrolysis is one of the most perspective methods of hydrogen production. Electrolysis technologies are developed and successfully implemented into practice in renewable and hydrogen energy. In particular, high effective environmentally-friendly systems of water electrolysis with polymer electrolyte membrane (PEM) are successfully linked with the plants producing the electric power using the renewable energy sources. The similar approach is extremely actual for development of the decentralized energy sector in those countries which do not produce the electric power in the large scales and/or do not have extended electricity network. For example, electrolytic grade hydrogen (and oxygen) can be produced with consumption of an electric current from the PV panel, wind turbine or other source using the renewable energy. At time periods, when a primary energy source is unavailable (at night, etc.), the accumulated gases are used in a fuel cell for electricity and heat production.

Thus it is important, that electrolysers with PEM are capable to produce gases under a high pressure (to 150 bar and above), that allows to carry out direct refueling of storage systems (for example, on the basis of gas vessels, metal hydrides etc.) without additional power inputs on the compression of gases.

The aspects of researches and optimization of water electrolysers with PEM provided in RRC "Kurchatov Institute" are reported in this communication. In particular, the physicochemical model of PEM water electrolyser (including operated at high pressures and temperatures) has been developed within the framework of the provided complex of investigations. Some feasibilities of optimization using the mathematical modeling with regards to the system electrocatalytic layer — a current collector are shown. New high effective nano-structured electrocatalysts (including on the carrier, and also mixed oxides compositions, such as $Ru_xIr_ySn_{1-x-y}O_2$) and electrocatalytic layers on their basis were synthesized and investigated. Chemical and physical techniques of electrocatalysts synthesis (including on the basis of mixed oxides) were optimized. R&D works on creation of new gas-proof membranes, bi-porous current collectors on the basis of titanium and carbon materials, non-platinum electrocatalysts are provided.

The provided complex of investigations has allowed to improve the specific performances of electrolysers and to lower their cost. Electrolysers with productivity up to 2 m^3/hour with operating pressure up to 30 bar (see fig. 1–3) were developed. These electrolysers allow in many cases to carry out the direct refueling of gas storage systems without energy-consuming process of compression. Power cost on hydrogen production is 4,0–4,3 kW·hour/m^3, hydrogen purity > 99,98% (without additional clearing), operation resource up to 10000 hours. Small-scale production of some types of electrolysers is organized. Developed electrolysers are used in various areas of power and mechanical engineering, in particular, for maintenance with hydrogen of laboratories, hydrogen refueling stations for motor transport. Creation of the new generation of water electrolysers, operating under the pressure of 130–160 bar with hydrogen productivity 10 m^3/hour is currently provided.

Financial support of R&D works is provided by the Federal Agency for Science and Innovations of the Russian Federation within the framework of the Federal Principal Scientific-Technical Programme "Researches and development on priority directions in development of scientifictechnological complex of Russia for 2007–2012", by NIC NEP company and also by the European Commission in the course of research project GenHyPEM (6^{th} Framework Programme).

Fig. 1. A photo of PEM water electrolyser
with productivity of 25 l/hour

Fig. 2. A photo of PEM water electrolyser
with productivity of 125 l/hour
(operating pressure up to 30 bar)

Fig. 3. A photo of PEM water electrolyser
with productivity of 1,5 m^3/hour,
operating under pressure to 30 bar