Investigations of hydrogen compressor based on proton exchange membrane

S.A. Grigoriev*[1], A.A. Kalinnikov[1], V.I. Porembskiy[1], V.N. Fateev[1], R. Blach[2]

[1] *Hydrogen Energy and Plasma Technology Institute of Russian Research Center "Kurchatov Institute", 123182 Moscow Russia, Kurchatov sq., 1*

[2] *David Systems and Technology S.L., Spain*

** S.Grigoriev@hepti.kiae.ru*

Proton exchange membrane (PEM) water electrolysers produce hydrogen and oxygen of the high purity by means of electrochemical decomposition of water. The present study is devoted to investigation of the possibility of electrolyser operation as a so-called "hydrogen compressor" (HC). Such electrochemical system is supplied with hydrogen or hydrogen-contain mixture on the anode, and pure (up to 99.99% and more) pressurized hydrogen is generated on the cathode by the following electrochemical reactions:

anode: $H_2 \rightarrow 2H^+ + 2$;

cathode: $2H^+ + 2 \rightarrow H_2$;

overall reaction: $H_2 \rightarrow H_2$.

HCs could be very useful for hydrogen purification or separation from different technological mixtures and waste gases (for example, from outlet gases of fuel cells, products of organic fuel conversion and so on). Therewith, the pressurization of the low-pressure hydrogen from the anode to the high-pressure hydrogen at the cathode (up to 150 bar and more using the cascade scheme) is possible without additional energy inputs.

Results reported in this communication are related more specifically with optimization of the membrane-electrode assembly for HC using both mathematical modeling and experimental study. In particular, the electrocatalytic layer composition was considered a function of HC operation mode (water vapor partial pressure, current density etc) and some recommendations for improving the HC efficiency were done. For instance, in order to improve rather complicated HC water balance, the ion-exchange polymer content in both cathode and anode electrocatalytic layers was considerably increased (up to 25 wt. %) in comparison with the conventional PEM fuel cells and electrolysers.

Besides, the operation parameters of HC have been investigated and optimized. For example, the optimum temperature regime was determined as 70°C for both the cell and the anode gas flow humidification.

The mentioned above improvements allow to achieve rather high performances of HC. For example, at a current density of 0.5 and 1.3 A/cm^2, the voltage was 0.160 and 0.390 V, correspondingly. No limitations were observed up to the 1.3 A/cm^2.