**Dimensionless approach of a pressurized proton exchange membrane water electrolysis**

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**Highlights**

* Proton exchange membrane water electrolysis
* Electrochemical compression/purification
* One dimensional modelling

**1. Introduction**

The global hydrogen consumption is around 50 Mton per year [1]. However, only a small part is used for energy device as an energy carrier. An energy carrier contains energy, facilitates its transport and storage before it is supplied (and converted) to an end user. Hydrogen fulfils the main characteristics to achieve the performance required for efficient energy carrier, but its low volume density remains a weak point. A very high energy-efficient compression is a necessary step. The main advantage of hydrogen production using water electrolysis is the simplicity of the process: only water and electricity are required. Water electrolysis allows to produce pressurized high purity hydrogen in order to facilitate the storage. Nowadays, mechanical compressors are considered to be the most commonly used in the industry. These systems enable to increase gas pressure by decreasing its volume using a mechanical force (energy). For multistage compression from room pressure to a final pressure of 20 MPa (200 bar), about 8% of the higher heating value (HHV) of the transported gas energy content (here hydrogen) is required [2]. Therefore, direct electrochemical compression is mainly advantageous for hydrogen to become a widespread renewable-energy carrier.

**2. Methods**

This work focuses on Proton Exchange Membrane Water Electrolysis (PEM-WE) which is considered as the most efficient process. In the literature, the analytical models and dimensionless approaches are essentially used for fuel cells. An interesting aspect of dimensionless study is the panel of dimensionless numbers specific to fuel cells including the Wagner number and the number of Damkholer. According to the author’s opinion, the analytical modeling and dimensionless methods are currently underutilized in fuel cell (PEMFC) and electrolysis domain (PEM-WE). The developed analytic approach in this work exhibits an innovative approach to quantify electrochemical performances based on dimensionless methodology.

**3. Results and discussion**

In the present work, the limiting processes are highlighted using the obtained dimensionless numbers. In the case of PEM-WE, the main phenomena are proton diffusion, electrochemical kinetics at catalytic layers, water transport: diffusion, electro-osmotic and osmotic pressure transport in the membrane [3]. Thanks to this mathematical procedure, it is possible to forecast electrochemical behavior and to grant optimal operating conditions. Equivalent Wagner number and Thiele modulus analogy are presented in this paper. Our dimensionless approach is used to scrutinize the mean values as well as the spatial distributions of current densities, over potential, water contents and membrane resistance. Therefore, it allows to frame the usual differential equations into a dimensionless equation set.

**4. Conclusions**

Direct electrochemical compression of hydrogen during electrolysis process have been successfully modeled using dimensionless approach. According to the resistive energy losses associated with proton diffusion through the electrochemical cell: doubling the current density, doubles the hydrogen flow, but quadruples the dissipated power. The specific resistance of the membrane is main parameter of electrochemical cell. The overall resistance depends on cell materials as well as operating conditions such as pressure gradient, contact resistance, diffusion profiles, and at the selected current density [4].

**References**

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