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In-situ Acoustic Emission Analysis of a Polymer Electrolyte Membrane Water Electrolyser

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Abstract : Increasing the efficiency of electrolyser technology is commonly seen as one of the main challenges on the way to the Hydrogen Economy. There is a significant lack of understanding of the different states of operation of polymer electrolyte membrane water electrolysers (PEMWE) and how these influence the overall efficiency. This in particular means the two-phase flow through the membrane, gas diffusion layers (GDL) and flow channels. In order to increase the efficiency of PEMWE and facilitate their spread as commercial hydrogen production technology, new analytic approaches have to be found. Acoustic emission (AE) offers the possibility to analyse the processes within a PEMWE in a non-destructive, fast and cheap in-situ way. This work describes the generation and analysis of AE data coming from a PEM water electrolyser, for, to the best of our knowledge, the first time in literature. Different experiments are carried out. Each experiment is designed so that only specific physical processes occur and AE solely related to one process can be measured. Therefore, a range of experimental conditions is used to induce different flow regimes within flow channels and GDL. The resulting AE data is first separated into different events, which are defined by exceeding the noise threshold. Each acoustic event consists of a number of consequent peaks and ends when the wave diminishes under the noise threshold. For all these acoustic events the following key attributes are extracted: maximum peak amplitude, duration, number of peaks, peaks before the maximum, average intensity of a peak and time till the maximum is reached. Each event is then expressed as a vector containing the normalized values for all criteria. Principal Component Analysis is performed on the resulting data, which orders the criteria by the eigenvalues of their covariance matrix. This can be used as an easy way of determining which criteria convey the most information on the acoustic data. In the following, the data is ordered in the two- or three-dimensional space formed by the most relevant criteria axes. By finding spaces in the two- or three-dimensional space only occupied by acoustic events originating from one of the three experiments it is possible to relate physical processes to certain acoustic patterns. Due to the complex nature of the AE data modern machine learning techniques are needed to recognize these patterns in-situ. Using the AE data produced before allows to train a self-learning algorithm and develop an analytical tool to diagnose different operational states in a PEMWE. Combining this technique with the measurement of polarization curves and electrochemical impedance spectroscopy allows for in-situ optimization and recognition of suboptimal states of operation.

Keywords : acoustic emission, gas diffusion layers, in-situ diagnosis, PEM water electrolyser
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