Proceedings of the 1st international Symposium on AI and Fluid Mechanics
Abstract No S15 A4

Development of a Digital Twin for Alkaline Water Electrolyzers

[1]Hamed Abedini[1,*]; Simona Bennici[1]; Armand Gering[1];

[1]Research and Innovation Department, John Cockerill Hydrogen, 4100 Seraing, Belgium

Abstract

Low-order models offer a computationally efficient alternative to Computational Fluid Dynamics (CFD) models, enabling reliable predictions of system behavior with significantly reduced processing time. These models are particularly suited for the development of advanced control systems, optimization frameworks, troubleshooting tools, and digital twins for various processes. This work presents a low-order dynamic numerical model for alkaline electrolyzers, capable of predicting key process outputs such as H_2 production rate, gas purity (O_2 in H_2), pressure, temperature, and electrolyte level in gas-liquid separators under both steady-state and transient conditions. Despite requiring computational times on the order of minutes—much faster than CFD models—the proposed model captures detailed phenomena such as gas crossover through the membrane, gas solubility in the electrolyte, and shunt currents. The model can also be used to estimate the variables that are difficult to measure, such as variation of KOH concentration in the lye and the flow rate in the balancing line between two separators. A computational framework in MATLAB is developed to solve this model. Comparison of the simulation results with the experimental data collected from different electrolyzers ranging from lab-scale test benches to industrial-scale systems, confirms the accuracy of the model. The model can be used to create a digital twin capable of iterative updates using real-time data. This digital twin will forecast the future behavior of the system, facilitating decision-making, fault diagnosis, and control processes.

Keywords: Low-order model, Alkaline electrolyzers, Dynamic modeling, Digital twin, Real-time simulation

[*] *Corresponding author: Hamed Abedini, E-mail address: hamed.abedini@johncockerill.com, Address: Rue Jean Potier 1 - BE 4100 Seraing, Belgium*