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Improving Alkaline Water Electrolysis by Using an Asymmetrical Electrode Cell Design

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Abstract : Hydrogen is an energy carrier with potential applications in various industries. Alkaline electrolysis is a commonly used method for hydrogen production; however, its energy cost remains relatively high compared to other methods. This is due in part to interfacial pH changes that occur during the electrolysis process. Interfacial pH changes refer to the changes in pH that occur at the interface between the cathode electrode and the electrolyte solution. These changes are caused by the electrochemical reactions at both electrodes, which consume or produces hydroxide ions (OH-) from the electrolyte solution. This results in an important change in the local pH at the electrode surface, which can have several impacts on the energy consumption and durability of electrolysers. One impact of interfacial pH changes is an increase in the overpotential required for hydrogen production. Overpotential is the difference between the theoretical potential required for a reaction to occur and the actual potential that is applied to the electrodes. In the case of water electrolysis, the overpotential is caused by a number of factors, including the mass transport of reactants and products to and from the electrodes, the kinetics of the electrochemical reactions, and the interfacial pH. An increase in the interfacial pH at the anode surface in alkaline conditions can lead to an increase in the overpotential for hydrogen production. This is because the lower local pH makes it more difficult for the hydroxide ions to be oxidized. As a result, there is an increase in the required energy to the process occur. In addition to increasing the overpotential, interfacial pH changes can also lead to the degradation of the electrodes. This is because the lower pH can make the electrode more susceptible to corrosion. As a result, the electrodes may need to be replaced more frequently, which can increase the overall cost of water electrolysis. The method presented in the paper addresses the issue of interfacial pH changes by using a cell design with a different cell design, introducing the electrode asymmetry. This design helps to mitigate the pH gradient at the anode/electrolyte interface, which reduces the overpotential and improves the energy efficiency of the electrolyser. The method was tested using a multivariate approach in both laboratory and industrial current density conditions and validated the results with numerical simulations. The results demonstrated a clear improvement (11.6%) in energy efficiency, providing an important contribution to the field of sustainable energy production. The findings of the paper have important implications for the development of cost-effective and sustainable hydrogen production methods. By mitigating interfacial pH changes, it is possible to improve the energy efficiency of alkaline electrolysis and make it a more competitive option for hydrogen production.

Keywords : electrolyser, interfacial pH, numerical simulation, optimization, asymmetric cell
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