STRATEGY FOR PH CONTROL OF ALL-IRON FLOW BATTERY ELECTROLYTES

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In the current context of the development of renewable energy and the growing need for high-capacity energy storage systems, all-iron flow batteries (AIFBs) are emerging as a promising alternative to traditional battery technologies. One of the key issues affecting the efficiency and longevity of AIFBs is the control of the state of charge and the pH of the electrolytes. Fluctuations in pH values can lead to an increased share of current in the side reaction of hydrogen evolution, electrode corrosion, the formation of insoluble iron compounds, and a decrease in battery efficiency.

The aim of the research is to develop and optimize a pH control strategy for electrolytes to enhance the stability and performance of the all-iron flow battery through an electrolyte regeneration system.

The research methods include:

1. Experimental study of the impact of pH on the electrochemical properties of electrolytes in IIFBs.
2. Development of a real-time pH monitoring and automatic regulation system.

The developed electrolyte rebalancing system uses a hydrogen/iron electrochemical cell for automatic pH control. Its operating principle is as follows:

- At the cathode of the electrochemical cell, hydrogen is oxidized to H^+ ions:

$$H_2 \rightarrow 2H^+ + 2\bar{e} \qquad (1.1)$$

- H^+ ions pass through the membrane into the posilyte, lowering its pH value.

- Simultaneously, the current flowing through the system promotes the reduction of Fe^{3+} ions in the posilyte to Fe^{2+} :

$$Fe^{3+} + \underline{\bar{e}} \rightarrow Fe^{2+} \qquad (1.2)$$

Thus, the system maintains an optimal pH balance in the electrolytes, ensuring stable battery operation and reducing side processes.

Key results:

Optimal pH ranges have been established for both catholytes and anolytes, ensuring maximum productivity and minimal material degradation. Improvement in the cyclic stability of the iron-iron flow battery (IIFB) has been demonstrated using the proposed pH control strategy.

Testing of various operational modes of the electrolyte regeneration system has been conducted, including regeneration during cell charging, discharging, and between cycles. The best results were achieved when the regeneration system operated during the discharging stage of the flow battery cell.

Experiments with different durations of the electrolyte regeneration process, ranging from 1 hour to 6 hours, have been conducted. It was found that optimal results are achieved when the duration of the regeneration process coincides with the duration of the discharging stage of the cell.

Conclusions: The proposed pH control strategy for electrolytes, based on the use of a hydrogen/iron electrochemical cell, provides significant improvements in the efficiency and longevity of iron-iron flow batteries. This opens up new prospects for the widespread adoption of IIFBs in energy storage systems based on renewable sources.

Keywords: all-iron flow battery, electrolyte pH, control strategy, stability, performance, electrolyte rebalancing.