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Extended Abstract

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Study on performance of alkaline water electrolysis

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Global warming caused by CO2 gas can no longer be ignored. Therefore, we are trying to contribute to reducing the problem with our electrolytic technology accumulated so far in our company. Our target is to develop a large of alkaline water electrolysis (AWE) plant with high performance and contribute to problem solving. The performance of AWE is largely classified and influenced by four factors of anode, cathode, separator and cell structure of electrolyzer. Here, the results of electrodes and separators are mainly explained in our evaluation. Considering the use of renewable energy as standard, electricity always fluctuates in the operation of AWE. Therefore, the components of the cell must be sufficient resistant to such fluctuations. Electrode: there are two types of activated coating to reduce the overvoltage of electrode. Our investigation revealed that the anode coating of thermal decomposition is not enough tough, but the dispersion electroplating such as Raney Ni showed good durability against 100 times shutdown. During the shutdown of operation, revers current pass through in the cell. The revers current deteriorates the electrode performance and the phenomena causes difficult for anode coating life. Each saving of anode oxygen overvoltage of thermal and electroplating is around 50 mV and 100 mV compared with bare Ni. Separator: In the AWE, electrolyte is the same in both anode chamber and cathode chamber, so that diaphragm instead of ion exchange membrane can be used as separator. The point of its performance is that low cell voltage and high purity gas can be obtained. Currently, AGFA and KHI diaphragm are considered to be applicable to large-scale AWE plants. The performance of our AWE plant was around1.8 V at 5 kA/m2 and 80ºC. Its performance is affected by the electrode to be used. The differences in cell voltage occur from 100 mV to 200 mV. Alkaline water electrolysis is the easiest methods for hydrogen production because of their simplicity. Although the simplicity is an advantage; reducing the energy consumption and maintaining the durability and the safety of these systems are the main challenges. In this paper, alkaline water electrolysis system, that uses cost effective electrode materials and magnetic field effects are presented. Cost effective electrodes such as high carbon steel, 304 stainless steel, 316L low carbon steel and graphite material are used for the hydrogen production. After the selection of the best electrode pair, effects of magnetic field to hydrogen production and change of current density are investigated for KOH electrolytes in different concentrations (5 wt%, 10 wt% and 15 wt%). According to the experimental observations the direction of the Lorentz Force affects the hydrogen production and current density. When the Lorentz Force is directed upward, it enhances the hydrogen production for 5 wt% and 15 wt% KOH solution by almost 17%. The increase in current density for 5 wt%, 10 wt% and 15 wt% concentration is 19%, 5%, 13%, respectively. Forced convection in the magnetic field enhances the separation of gas bubbles from electrode surface. Downward directed Lorentz Force decreases hydrogen production and current density values significantly. For 5 wt%, 10 wt% and 15 wt% the hydrogen production decreases by 14%, 8%, 7%, respectively. Similarly, current density for downward directed Lorentz Force decreases by 11%, 7%, 4%, respectively.

In order to realize future hydrogen society, hydrogen production systems must meet the large demand of hydrogen usage. Alkaline water electrolysis (AWE) would be one of the candidate technologies to produce hydrogen on a large scale from renewable energy. We have conducted basic research into AWE, trying to reveal technical issues under zero gap system in new cell technology. The zero gap system contributes lower cell voltage without causing any major operating problems compared with conventional finite gap cell. However, it was observed that Ni base electrodes showed corrosion phenomena in a number of test trials including steady operating conditions and several shut-downs. Activated Raney Ni alloy coating for anode material had an advantage for oxygen overvoltage. It showed a saving of around 100 mV at 40 A/dm2 (0.4 A/cm2) against Ni bare anodes. In the Chlor–Alkali (C/A) industry, thermal decomposition coating of mixed noble metal on Ni substrate is commonly used for advanced activated cathodes. It showed very low hydrogen over-potential of around 100 mV in AWE. To achieve better cell performance, separator selection is very important. We evaluated several separators including ion exchange membrane (IEM) to understand the basic function in AWE. IEM for C/A electrolysis showed high cell voltage (over 2.2 V) but low O2 impurity in H2 gas. Hydrogen purity was over 99.95%. Porous separators made of polypropylene showed 1.76 V at 40 A/dm2 (0.4 A/cm2), 80 °C. But there was a weakness on the durability for continuous operation. Proper selection of separator is important in an actual plant for effective and safe cell operation. The concept of safety operation is referred to by diffusion coefficient of hydrogen.

Bottom Note: *This work is partly presented at 3rd International Conference on Electrochemistry July 10-11, 2017, Berlin, Germany*