Feasibility Study of Hydrogen Production System Using Salinity Difference between Treated Wastewater and Seawater (B-DASH)

(Research for FY 2016-17)

1. Purpose

Recently, people pay attention to hydrogen as a next generation energy resource. Also in the field of wastewater, utilization of hydrogen is considered such as a practical application of hydrogen production from digestion gas.

This study deals with Reverse electrodialysis (RED) technology that generates electricity using a salinity difference between freshwater (treated wastewater) and seawater. The purpose of the study is to verify that the RED technique electrically decomposes water to generate hydrogen and consider a practical application of the hydrogen production technology using a salinity difference.

This research is adopted as B-DASH feasibility study[*1] 2017 of MLIT[*2]. The consortium of Yamaguchi University; Seiko Electric Co., Ltd; Japan Sewage Works Agency (JS) conducts the feasibility study as an entrusted research project of NILIM[*3].

*1.B-DASH Project: Breakthrough by Dynamic Approach in Sewage High Technology Project
*2.MLIT: Ministry of Land, Infrastructure, Transportation, and Tourism
*3.NILIM: National Institute for Land and Infrastructure Management

2. The Achievements of year 2016

It was verified that the experiment using concentrated seawater and treated wastewater as raw water produced hydrogen. Besides, it was confirmed that seawater and treated wastewater filtrated in the pre-treatment process maintained the performance of hydrogen production for more than 1,000 hours.

3. Achievements of this year

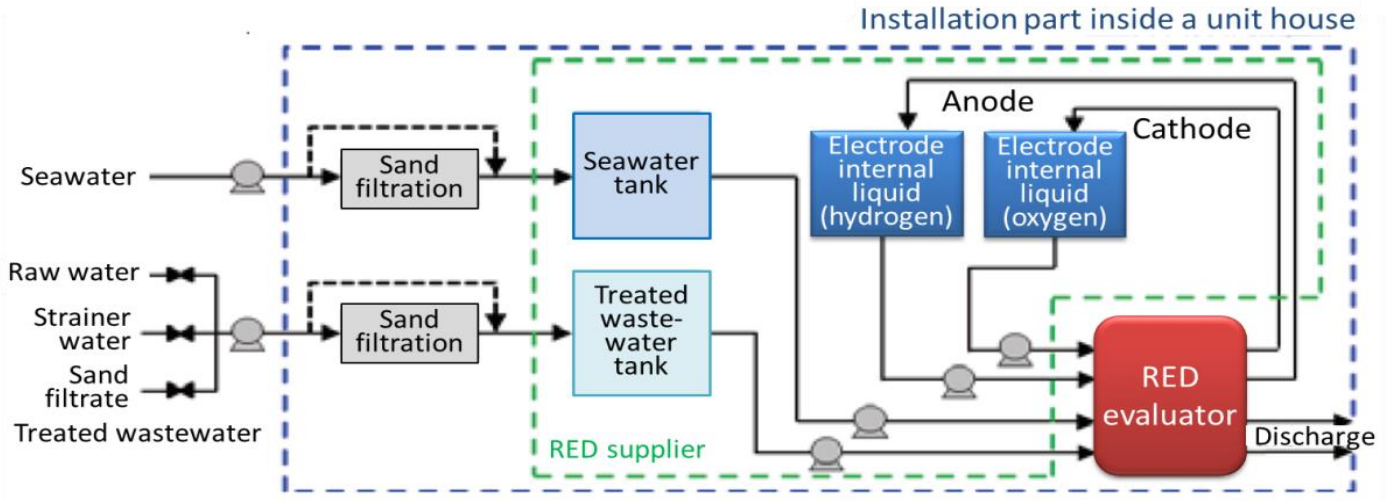

Figure 1: Flow diagram of the test equipment

Research team established experimental equipment (figure 1) in Tokuyama East WWTP in Shunan City in addition to Yamaguchi University for the investigation and consideration using treated wastewater and seawater.

- The newly adopted stack with smaller intermembrane spaces reduced resistance of the solution. The new configuration increased the quantity of hydrogen production 1.88 times more than that of the last years and achieved the hydrogen conversion efficiency of 96%.
- The purity of generated hydrogen was 94.0% (theoretical value after the adjustment by dehydration.) Since impurity was supposed to be caused by aeration, an airtight design should be considered.

- In the investigation using sand filtrated treated wastewater and seawater, a regular backwash enabled continuous operation for 750 hours with no decline of power output.
- The internal resistance of the hydrogen production device depends on water temperature. It was verified that power output increased by 3% when the temperature rises of 1℃.
- It was verified that some optimizations reduced resistance and generated more electricity; the optimized requirements were the intermembrane spaces of positive and negative ion exchange membranes alternately arranged inside the stack, use other membranes such as monovalent ion selective membrane and membrane with different resistance, and the electrode construction.
- All sorts of pre-treatment were compared. Sand filtration was judged to be the most stable both for seawater and treated wastewater.
- The reverse flow of seawater and treated wastewater supplied to the RED hydrogen production device could maintain the salinity difference inside the stack and prevent the decline of electromotive force.
- Supposing the FS technology is popularized in 2030, researchers estimated the cost reduction effect of RED hydrogen production devices. Assuming neither pretreatment process for treated wastewater such as membrane separation bioreactor or hydrogen purification device were required, the estimation showed that RED system with the treatment capacity of 30,000m^3 recovers its costs in 14.6 years and the unit price of hydrogen production is 95 Japanese yen/ Nm^3.

4.Conclusion

At the moment, the unit price of hydrogen production by the FS technology is still high. For the future popularization, the RED hydrogen production system requires its performance improvement and the establishment of

pretreatment technology; for example, the reduction of stack's membrane resistance, the study of fouling and increasing in size of the system.

Keywords: Hydrogen, Reverse electrodialysis, RED, Energy from salinity difference, Electrolysis, Seawater, Wastewater