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Deep Ocean Water Applications Society

On Receipt the FY2016 "Energy Conservation Prize"

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The "Energy Saving Efforts Utilizing Waste Heat in Salt Manufacturing Factories" carried out in collaboration between Kochi University of Technology, Shikoku Electric Power Company, and the Japan Electro Heat Center, received commendation from the Director General of the Agency for Natural Resources and Energy in the Energy Conservation Division of the Energy Conservation Grand Prize this year.

This award is for the introduction an electric heat pump concentrator in lieu of steam kettles utilizing fossil fuels for salt water concentration processes at salt manufacturing plants through the utilization of the waste heat typically discharged into the atmosphere and introduction of reverse osmosis membranes. Through multiplexing, etc., energy consumption is reduced by 93%, and a superior energy saving property is obtained.

1. Background and Circumstances

(1) The Manufacturing Process of Natural Salt

In order to obtain salt from seawater, it is necessary to evaporate enormous amounts of water to concentrate seawater to about 3% salt.

Figure 1 shows the traditional manufacturing process. First, water is passed through a Reverse Osmosis (RO) membrane to concentrate seawater from 3% to 4.5%. Next, the saltwater is further concentrated from 4.5% to 23%, close to a saturated solution, by evaporation with a steam kettle. The next step is to precipitate salt through evaporation and concentration of sea water through steam cooking for precipitation. Finally, salt is centrifuged which separates the salt and bittern. When complete "Muroto Salt," "Deep Sea Flower," and "Bittern" are sold under the Muroto Deep Seawater Brand.

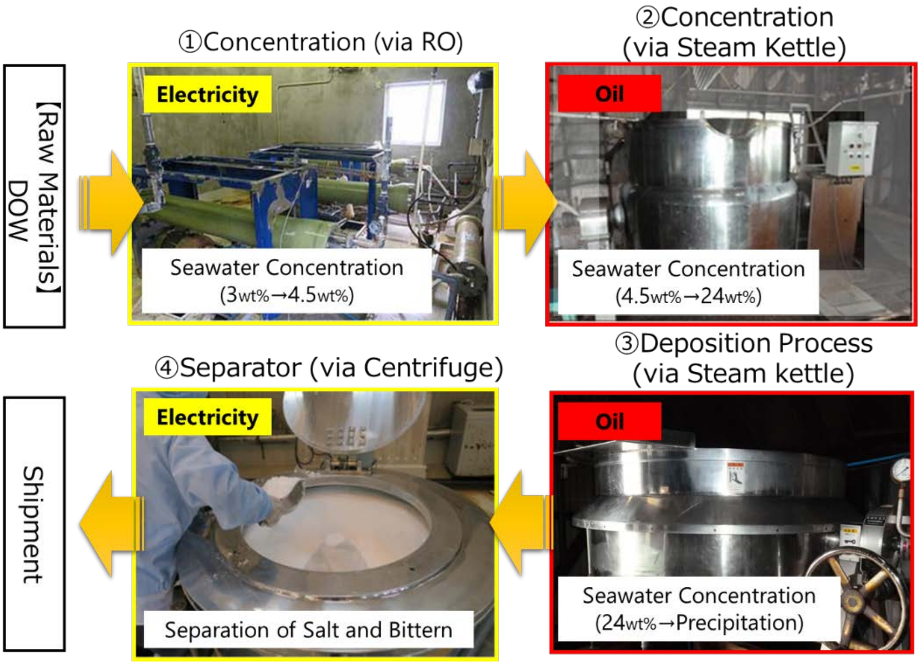

Figure 1. Manufacturing Process

(2) Manufacturing Cost and Energy Usage

Figure 2 shows the ratio between the production cost of natural salt and energy usage by manufacturing process. The cost of heavy oil grade A accounted for 37% of the manufacturing cost and 82% of the energy consumption was the steam kettle of the evaporation concentration process.

Therefore, as “the maximum reduction of heavy oil grade A through energy saving in the evaporation concentration process” was our biggest management task, and we decided to make the company’s energy conservation activities a priority throughout the company.

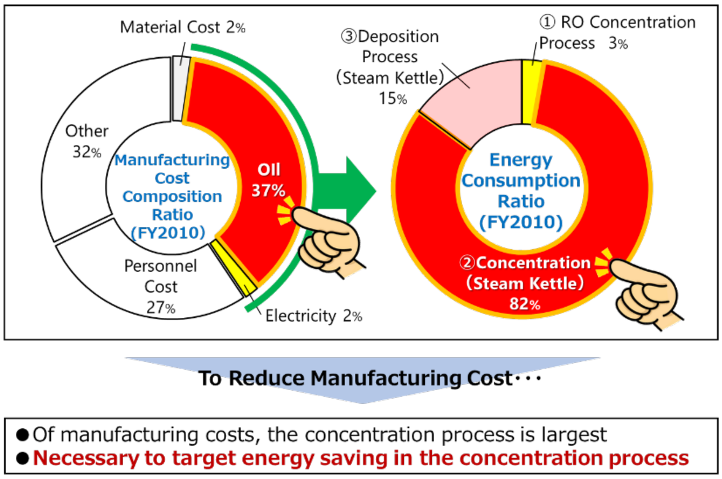

Figure 2. Necessity of Energy Use and Energy Saving

2. Energy Conservation Viewpoint and Content

(1) Improvement of Membrane Separation Process

In the conventional membrane separation process, a single-stage RO membrane concentrated salt from 3% to 4.5% prior to a steam kettle. In this effort, we added a Nanofiltration (NF) membrane and another RO membrane to prevent precipitation of calcium sulfide, and succeeded in concentrating the salt to 10% by three-stage membrane separation (Figure 3).

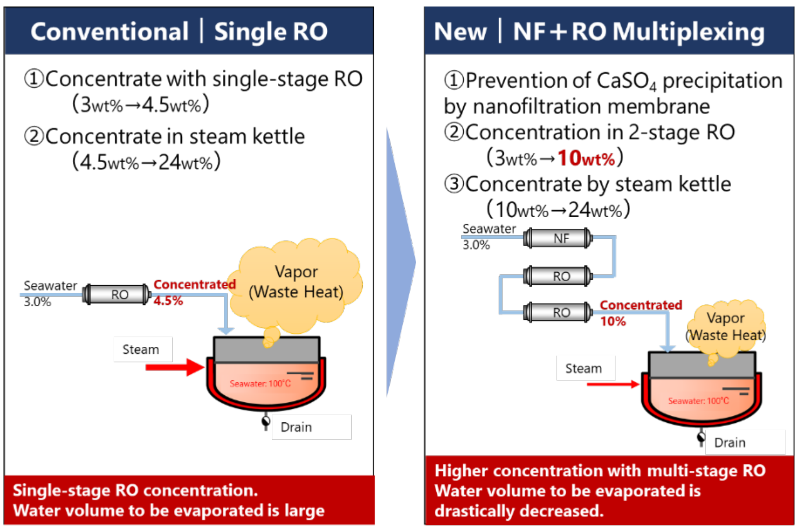

Figure 3. STEP 1 NF Membrane＋RO Membrane Multiplexing

By concentrating salt to 10%, we greatly reduced the amount of water to be evaporated when concentrating in a steam kettle. With this (STEP 1) alone, we were able to reduce the amount of energy (equivalent to crude oil) to produce 1 kg of salt from 1.76L to 0.62L.

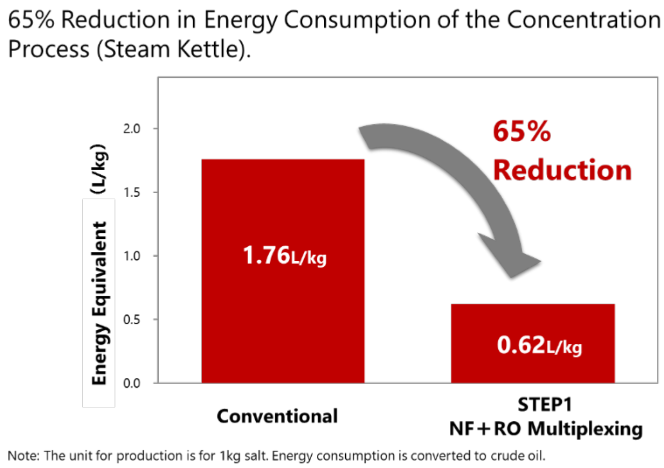

Figure 4. Energy Saving Effect (STEP 1 NF membrane + RO membrane multiplexing)

（２） Waste Heat Utilization in the Evaporation Concentration Process

In conventional steam kettles, moisture is evaporated through thermal energy input and released to the atmosphere in the form of water vapor. Therefore, focusing on this unused waste heat, we tried to utilize it through heat pump technology. In evaporative concentration utilizing waste heat (Figure 5), the kettle is shut down in a decompressed state. Water vapor, which was traditionally released to the atmosphere is recovered as saturated steam at 60℃, and is subsequently raised to 70℃ through adiabatic compression with a heat pump. Finally, the principal is to reuse the steam as a heating source for the evaporation pot. As a result, it was possible to recycle the waste heat released to the atmosphere in its entirety and recycle it, leading to a significant reduction in input energy (Figure 6).

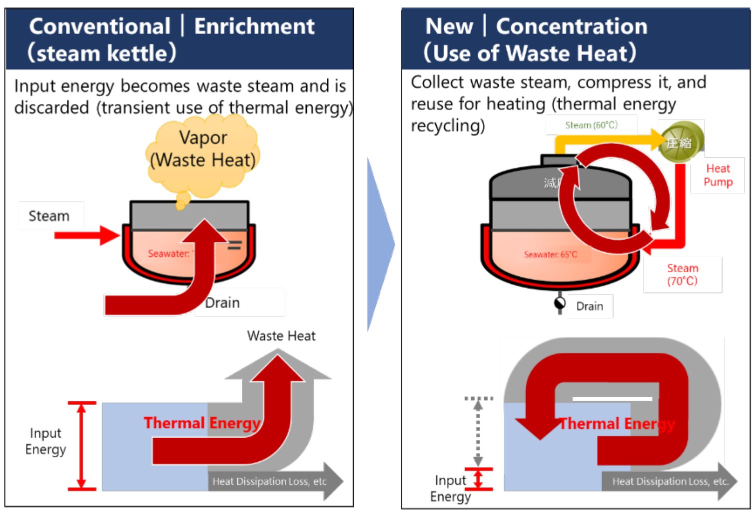

Figure 5. STEP 2 Waste Heat Utilization

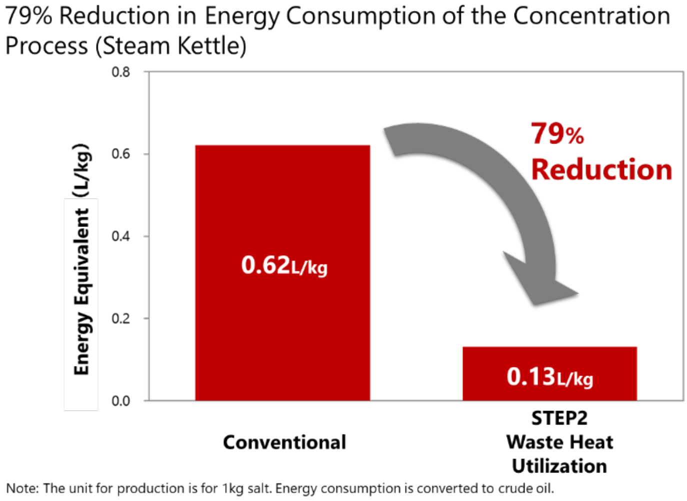

Figure 6. Energy Saving Effect (STEP 2 Waste Heat Utilization)

Figure 7 shows the type of heat pump type vacuum concentration device (VRC device) introduced. Heated steam (70℃) by the heat pump had been structured to flow through a heating tube. In introducing this equipment there were many technical problems such as scaling countermeasures on the heating pipes, metal corrosion due to salinity, rise in boiling point due to increased concentration of seawater, and the influence on product quality. With the enhancement of the membrane separation process, the effect of inhibiting calcium sulfate and the selection of a material resistant to corrosion, we have been able to operate for more than a year without problems.

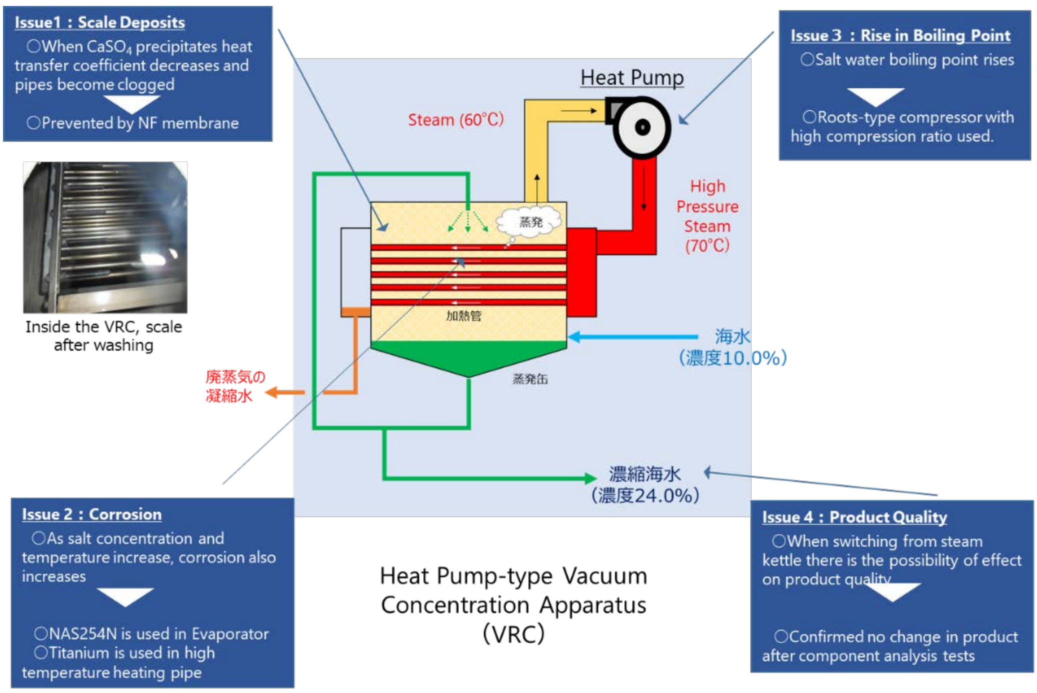

Figure 7. Issues and Solutions to VCR Equipment

3. Achievements

As mentioned above, energy saving of 65% due to a more sophisticated membrane separation process and 79% savings through utilization of waste heat in the evaporation and concentration process enabled reduction in energy consumption of 93% in the entire concentration process. As a result of greatly reducing the amount of energy used in seawater concentration process as described above, we were able to reduce the energy consumption of the entire manufacturing process by 76% This corresponds to a reduction of 487kL per year in crude oil equivalent if the annual production volume is 300tons. As a result of this success, we were able to attain the "great reduction of heavy oil grade A through energy saving in the evaporation concentration process" which was listed as our main management issue. At present our company is proceeding to increase product production and expand sales channels.