# A NEW ELECTRODIALYZER TECHNIQUE FOR THE SALT PRODUCTION BY ION-EXCHANGE MEMBRANE

Mitsugu Yamamoto[a], Fumio Hanada[a], Shigeo Futaki[b] and Kazuyuki Takashima[b]

[a] Tokuyama Corporation Tokuyama City, Yamaguchi Japan

[b] Sanuki Salt Manufacturing Co., Ltd., Sakaide city, Kagawa, Japan

Tokuyama Corp. has been supplying the electrodialyzers and ion-exchange membranes to Sanuki Salt Manufacturing Co., Ltd. and Kinkai Salt Manufacturing Co., Ltd. for use in the seawater concentration facilities by ion-exchange membranes.
A number of developments and renewals of the ion-exchange membranes and the electrodialyzers have been made, which have resulted in excellent performance of the total system. The present theme of the development is to achieve a system that operates with even higher stability and efficiency.

## 1. Introduction

The ion-exchange membranes have been used in the salt production and an increasing number of other applications. In the salt production, which has been the base in Japan for the technical development of the ion-exchange membrane, the electrodialyzer is being switched over to the energy-saving type to reduce the salt production cost. That is, improvement of the membrane is in progress to achieve lower electric resistance, higher NaCl brine concentration, and monovalent cation permselectivity, as well as the development of electrodialysis technique, such as, reducing the thickness of the seawater compartment and minimizing current leakage.

Although Tokuyama Corp., former Tokuyama Soda Co., Ltd., originally adopted the unit cell type electrodialyzer because of easy maintenance and control, the company started development of the filter press type electrodialyzer from the viewpoint of energy saving. Since the completion in 1976 of a large filter press type electrodialyzer, model TSW-200, the development efforts were continued, which realized an energy-saving type electrodialyzer, model TSX-200, and a new ion-exchange membrane, NEOSEPTA CIMS ACS-3.

The government has decided to abolish its salt monopoly in 2002, which has accelerated all the seven salt manufacturing companies to improve the manufacturing system to reduce the production cost, in an attempt to compete with domestic and foreign manufacturers.

Sanuki Salt Manufacturing Co. and Kinkai Salt Manufacturing Co., Ltd. users of Tokuyama's electrodialyzers are also striving to improve the electrodialysis technique and its operation method to reduce the production cost.

This report deals with the circumstances, in which the two companies mentioned above switched over from the electrodialyzer model TSW-200 to TSX-200, as well as the recent technical development themes, and the operation method and results of TSX-200 electrodialyzer.

## 2. Development of filter press type electrodialyzer

From 1967 through 1975, Tokuyama Corp. delivered the unit cell type electrodialyzers with annual production of 180,000 tons to Kinkai Salt Manufacturing Co. and Sanuki Salt Manufacturing Co. respectively, out of seven salt manufacturing companies in Japan. Thereafter, the filter press type electrodialyzer, model TSW-200, which was developed for the purpose of reducing power consumption, replaced the former unit cell type electrodialyzer in the respective companies. In 1983, Tokuyama completed an energy-saving electrodialyzer, model TSX-200 (Shimamura et al. 1990). A monovalent cation permselective membrane was developed (Hanada et al. 1990), and the pretreatment technique of seawater was put to actual use. The reduction in power consumption and the cleaning of the electrodialyzer without disassembly were successfully achieved (Tomita et al. 1993).

At present, in Sanuki Salt Manufacturing Co., seven electrodialyzers, model TSX, and one electrodialyzer, model TSW are producing 230,000 tons/year.

## 3. Electrodialyzer system, model TSX-200, and operation results

The system is comprised of a pretreatment facility to clean seawater and an electrodialyzer facility. Fig. 1 shows the outline flow of the electrodialyzer system, model TSX-200. The coagulating two-stage sand filter system is adopted for pretreatment of seawater to achieve high-precision filtering.

In this system, pumped up raw seawater is supplied with oxidizing agent and coagulating agent before it is led to the 1st sand filter. The adding conditions are somewhat varied according to the seawater characteristics. The 1st sand filter almost completely entraps and removes turbidity in raw seawater. The 2nd sand filter entraps the minute turbidity not removed by the 1st sand filter.

Fig. 2 shows the average annual turbidity of seawater and the seawater quality after pretreatment, both measured at Sanuki Salt Manufacturing Co.

Although the turbidity of raw seawater varies between 1 ppm and 7 ppm, the quality of the treated seawater is almost constant after filtering by varying the amount of additives and filter back washing time .

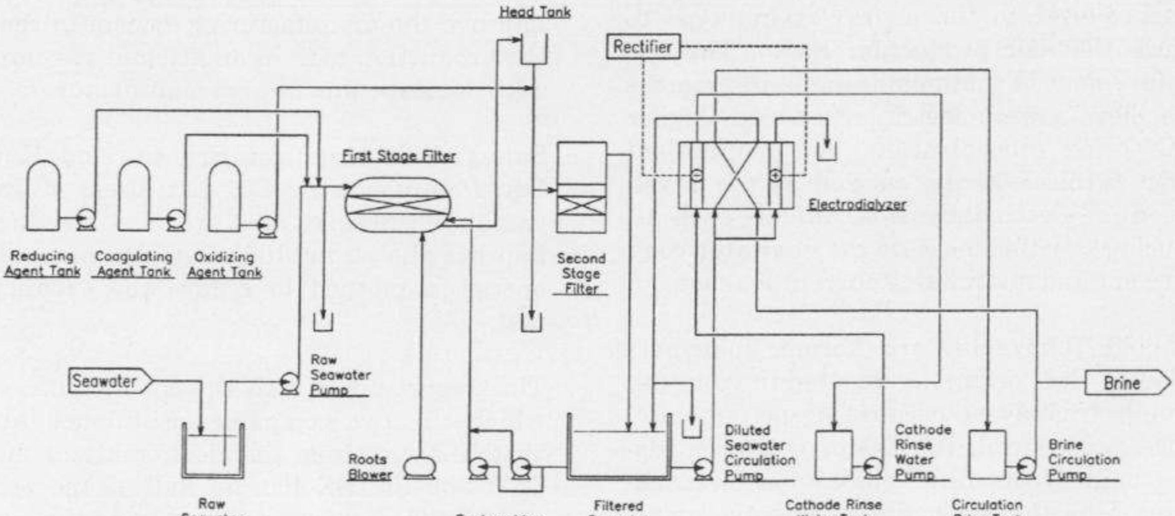
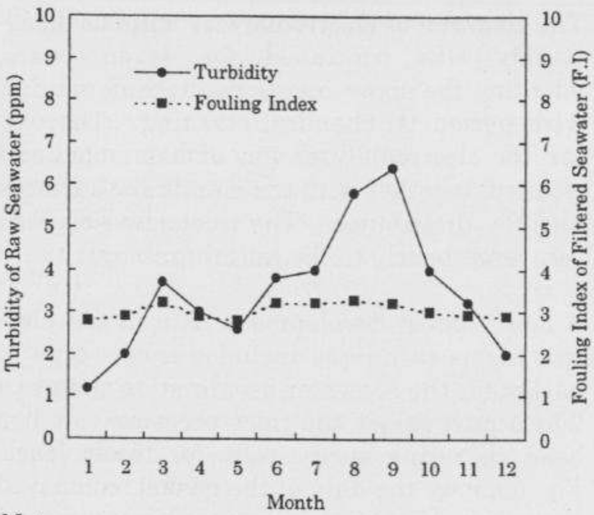



Figure 1. Flow diagram of the TSX-200 electrodialyzer system.




Note :

1) Represented turbidity unit (ppm) is Kaolin-turbidity unit
2) F.I ( Fouling Index ) is equal to SDI. ( Silt Density Index )

Figure 2. The annual turbidity level of raw seawater and FI value of the filtered seawater

On electrodialyzer :

Table 1 shows the specifications for the filter press type electrodialyzer, model TSX-200.

In the course of development, the unit cell type electrodialyzer at Sanuki Salt Manufacturing Co. was replaced by the press type electrodialyzer TSW-200 filter, and then by the filter press type electrodialyzer TSX-200 successively. Fig.3 is a diagram of operation results, showing the power consumption unit for the electrodialysis and NaCl brine concentration .

It illustrates the performance in the higher product brine concentration and the lower power consumption from the original unit cell type to TSW-200, and then to TSX-200 successively. As regards the durability of purity of ED brine of the monovalent cation permselective membrane NEOSEPTA CIMS, Fig. 4 shows that the operation is stable with established technique for permselective treatment conditions.

Table 1.
Specifications and design performance of the TSX-200 electrodialyzer

| | |
|---|---|
| 1. Specifications | |
| Ion-exchange membrane ( cation / anion ) | CIMS/ ACS-3 |
| Effective membrane ( $m^2$ ) | 2 |
| Thickness between membranes ( dilute side / concentrate side ) | 0.4/0.4 |
| Number of membranes ( pairs ) | 3,500 |
| 2. Operation condition | |
| Current density ( $A/m^2$ ) | 300 |
| Flow rate of seawater ( cm/sec ) | 6 |
| Temperature of seawater ( ℃ ) | 25 |
| 3. Performance | |
| Production capacity (t-NaCl/year) | 30,000 |
| NaCl concentration of brain ( g/L ) | 205 |
| Power consumed by electrodialyzer ( DC-kWh/t NaCl ) | 155 |

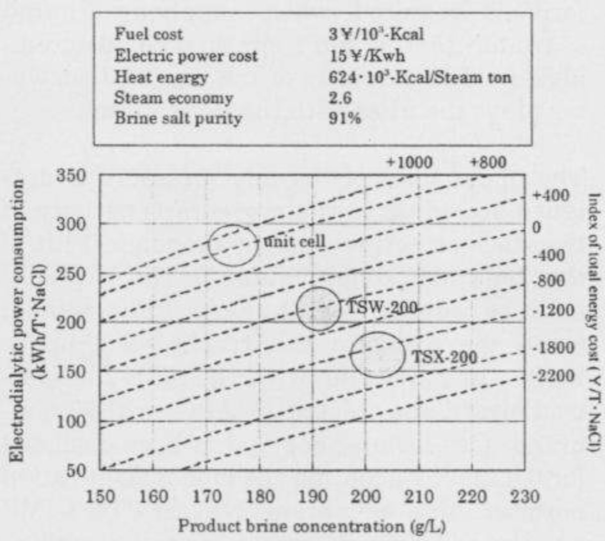



Figure 3. Power consumption for the ED and NaCl brine concentration

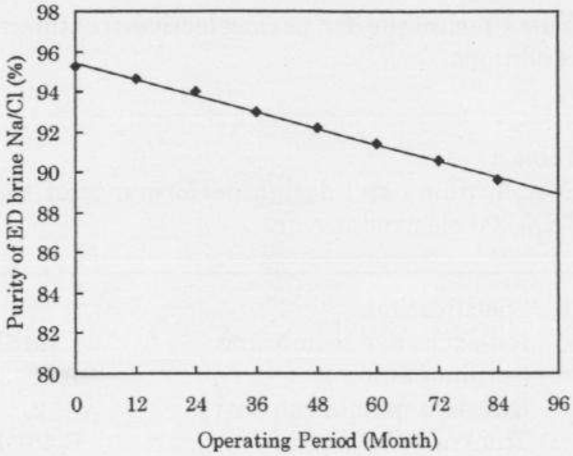



Figure 4. The operation results of monovalent permselective membrane.

## 4. Development items

In an attempt to reduce the production cost, Sanuki Salt Manufacturing Co. and Tokuyama Corp. have concentrated their endeavor on the following items.

### (1) Improved desalination gaskets of electrodialyzer and further improvement of electrodialyzer cleaning without disassembly

Because of the cell stack structure, pushing force is required when supplying filtered seawater to the filter press type electrodialyzer. The turbidity of the supplied seawater plugs the filter with the lapse of time.

The upper limit of the inlet pressure is designed according to the pressure resistivity of the stack structure and the economical lift of the seawater supply pump. The pressure must be reduced by cleaning or other method, when the pressure has reached the upper limit. In particular with the TSX-200 electrodialyser, the thickness between the membranes for seawater supply has been designed for 0.4 mm by adopting the monovalent cation permselective membrane NEOSEPTA CIMS and the advanced pretreatment technique.

The cleaning of electrodialyzer without disassembly was continued for seven years, adopting the above-mentioned techniques and with periodical chemical cleaning. Thereafter, the electrodialyzer was disassembled and cleaned, together with the membrane surfaces and the distributor. The inlet pressure was recovered nearly to the initial pressure.

A more recent development item in the electrodialysis technique includes a new type of gasket for the seawater desalination chamber, which part raises the inlet pressure. It has been operating successfully for three years. Fig. 5 shows the data of the gasket, compared with that of the cleaning technique without disassembly for seven years. The improved desalination chamber gasket reduces the plugging by foul material sticking to the inlet part. One of the features of this new gasket is that the pressure may be recovered almost to the initial pressure, when the seawater supply is temporarily stopped and seawater in the electrodialyzer is let to flow backwards by itself. This lengthened the cleaning period from every three months to every ten months, thus reflecting on the production cost, i.e., less cost for chemical cleaning, less number of workers and less frequent damage of the membrane at the time of disassembly and cleaning.

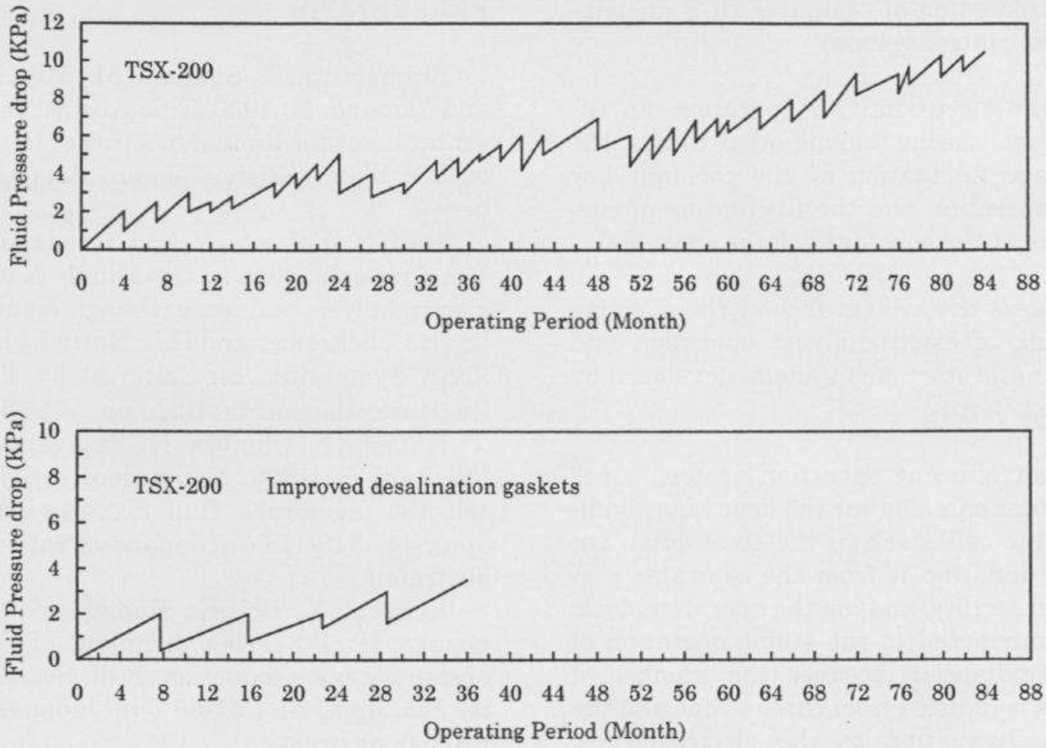



Figure 5. Fluctuation of fluid pressure drop through the stack in the ED

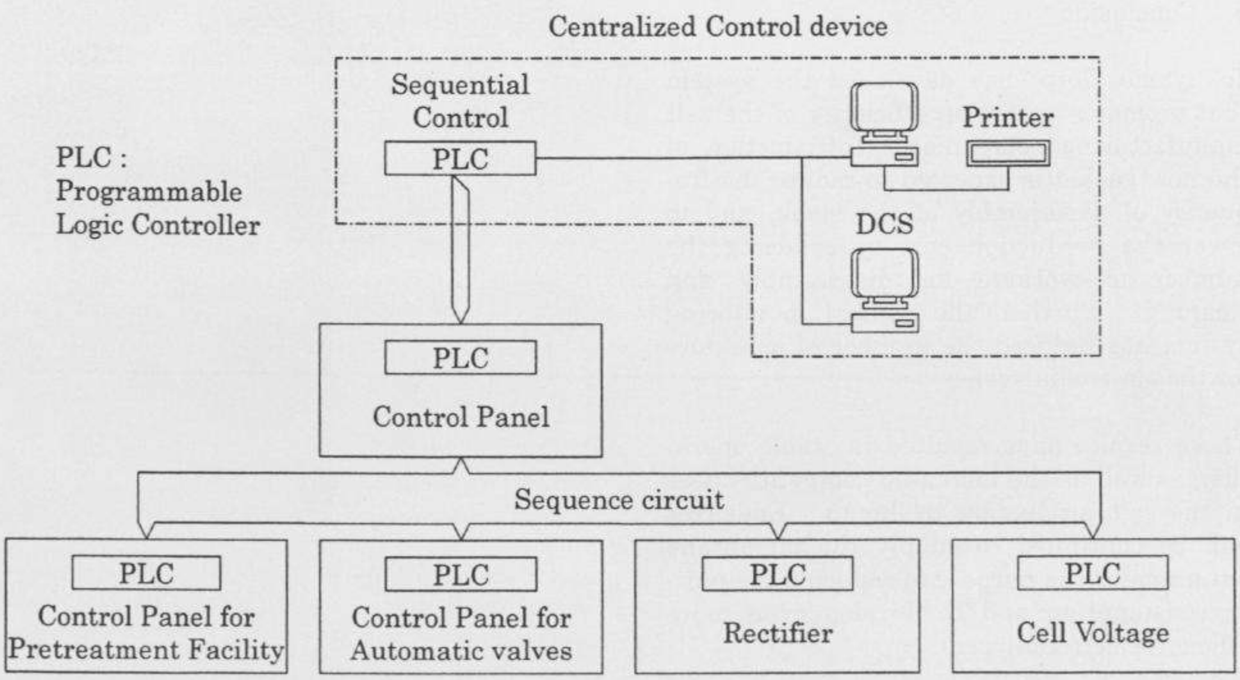



Figure 6. Construction of Computer DCS ( Distributed Control System )

(2) Introduction of computer DCS (distributed control system)

During the electrodialyzer operation, an operator is monitoring, among other things, the cell voltage fluctuation at the constant low current operation and the fluctuation of current value at the constant voltage operation.

Fig. 6 shows the system flow of the effective monitoring of electrodialyzer operation and the automatic start-stop system, developed by Tokuyama Corp.

This is an efficient operation system, since one operator can monitor the operating conditions of the cell stack in the electrodialyzer, start up and stop it from the seawater pretreatment facility, and log the operation data. It has contributed to the stable operation of the electrodialyzer, because the number of operators is reduced from three to one and the pressure fluctuation to the electrodialyzer and to the ion-exchange membrane due to start up and stop is minimized.

## 5. Conclusion

Tokuyama Corp. has developed the system that promotes operation efficiency of the salt manufacturing companies. Introduction of the new gasket is expected to reduce the frequency of disassembly of the stack, and to lower the production cost by reducing the number of workers for disassembly and cleaning. Further, the central monitoring system has reduced the number of operators for the electrodialyzer.

Those results have resulted in stable operation, as well as the increased competitiveness in the salt production in Japan. Endeavor will be continued to supply the membrane optimum for the purpose of reducing the power consumption and to develop even more efficient electrodialyzers.

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