



Mercury Free Technology in the Chlor-Alkali Industry

Background

Mercury Use in the Chlor-Alkali Industry

Caustic soda (sodium hydroxide) is a chemical substance that is indispensable in our daily lives. It is produced by the electrolysis of brine (salt water), which yields caustic soda, chlorine, and hydrogen.

There are three main processes used in this production: the mercury cell process, the diaphragm process, and the ion-exchange membrane process. However, due to growing social concerns about the environmental impacts associated with the use of mercury, the number of facilities using the mercury cell process has significantly decreased.

Requirement of the Minamata Convention on Mercury (Article 5 and Annex B)

Article 5 of the Minamata Convention regulates manufacturing processes using mercury or mercury compounds. It is stated that the mercury use for chlor-alkali production shall be phased-out by the end of 2025 (although some Parties may be granted an extension until 2030).

Overview of the Technology

Types of Processes Used in the Chlor-Alkali Industry and their Historical Development in Japan

During the rapid economic growth period in the 1970s, the mercury-cell process was most common in the chlor-alkali industry, and the amount of mercury used in this process accounted for more than half of the total amount of mercury used in Japan. However, due to environmental concerns, the mercury-cell process was completely phased out in 1986. The diaphragm process was subsequently used for some time, but today the mercury-free ion-exchange membrane process has been fully adopted in Japan.

Mercury process

As the name suggests, this process uses mercury in the production process and, due to environmental concerns associated with mercury use, is no longer used in Japan.

Diaphragm process

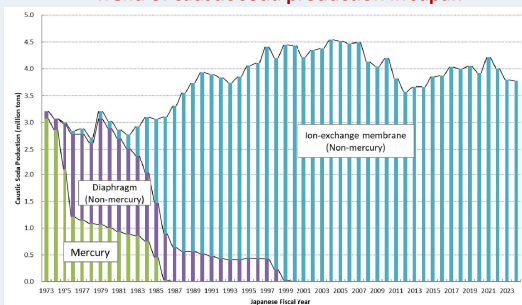
Diaphragm process utilizes a diaphragm consisting of asbestos to separate caustic soda and chlorine by dividing the anode and cathode compartments, without the use of mercury.

Ion exchange membrane process

The design of the ion-exchange membrane process is similar to the diaphragm cell, except that it does not use mercury and instead uses a cation-permeable ion-exchange membrane to divide the electrolytic cell into two sections. Only sodium ions and a small amount of water pass through the membrane to the cathode side, while chlorine is generated and collected at the anode.

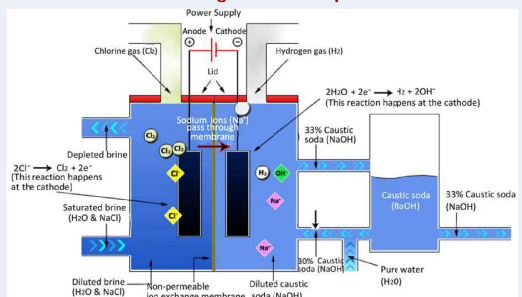
When the electricity consumption of the three processes is compared, the ion exchange membrane process has the lowest power consumption and is therefore more economical and energy-efficient.

Trend of caustic soda production in Japan



Source: "Lessons from Minamata Disease and Mercury Management in Japan" (Ministry of the Environment, Japan) https://www.env.go.jp/chemi/tmms/pr-m/mat01/en_full.pdf

Ion exchange membrane process

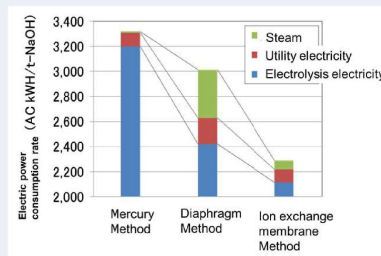


Source: Euro Chlor (<http://www.eurochlor.org>)

Co-Benefits from Conversion

When the Japanese industry started to use the ion-exchange membrane process, two major challenges were high energy consumption and the quality of caustic soda. However, extensive R&D improved the current efficiency to about 96%. Today, Japan's ion-exchange membrane technology can produce high-quality (high-purity) products while achieving significant energy savings, with electricity consumption less than 30% of that required by the mercury or diaphragm processes.

Energy efficiency comparison



Source: AGC Inc.

Ion-exchange membrane equipment



Photo provided by AGC Inc.

Conversion to ion-exchange membrane ensures the following "CO-BENEFITS": the reduction of energy consumption and the elimination of hazardous chemicals (e.g., mercury, asbestos) in the system. Furthermore, membranes manufactured in Japan have a high durability (long lifetime) thus ensuring stable operation of the system; these are factors essential for profitable operations of the chlor-alkali industry.

Applicability

World wide Use

Japanese ion-exchange membranes are used in electrolytic chlor-alkali plants in more than 50 countries, including China, EU, and the United States.

Challenges to Technology Adoption

Although ion-exchange membrane processes are more energy-efficient and profitable in the long term than mercury-cell processes, the initial investment required for conversion is high, and recovering the investment takes considerable time. However, in recent years, energy-saving ion-exchange membranes have been developed, making it possible to further reduce electricity costs.

The excess mercury recovered from decommissioned mercury cell must be disposed of in environmental sound manner. As the waste management is not profit-producing component, the process transition plan must incorporate the waste management within the feasibility study.

Further Reading

Detailed information about this technology can be found in the following website.

- Lessons from Minamata Disease and Mercury Management in Japan (https://www.env.go.jp/chemi/tmms/pr-m/mat01/en_full.pdf)
- UNEP, Mercury Reduction in the Chlor-Alkali Sector (<http://www.unep.org/chemicalsandwaste/global-mercury-partnership/mercury-reduction-chlor-alkali-sector>)

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