

Mercury Free Technology in the Chlor-Alkali Industry

Background

Mercury Use in the Chlor Alkali Industry

The mercury-cell process has been widely used for the production of chlorine and caustic soda. Concerns about the environmental impact of using mercury have led to a reduction in the number of mercury-cell. However, the process itself is still widely used in many countries.

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 2025.

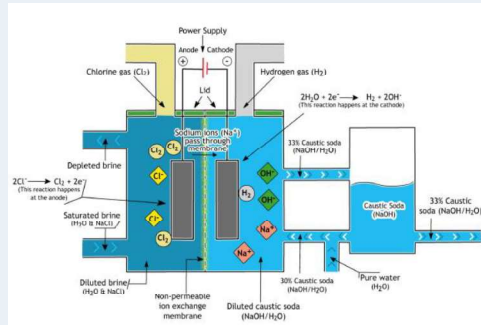
Overview of the Technology

Types of processes used in the Chlor-Alkali Industry

Caustic soda (sodium hydroxide) and chlorine are predominantly manufactured by the electrolysis of sodium chloride solution (Brine). Conventionally, *mercury process* and *diaphragm process* were used for the electrolysis process. Using *ion exchange membrane process* provides a lot of economic and environmental advantages and hence the conventional processes are being replaced by the ion exchange membrane process.

Mercury process, as the name suggests, utilizes mercury in the production process and is being phased out due to environmental challenges associated with the use of mercury. *Diaphragm process* utilizes diaphragm consisting of asbestos to separate the anode and cathode. The design of the *ion exchange membrane process* is similar to diaphragm cell except that a cation permeable membrane acts as an ion exchanger and divides the cell into two sections. Only sodium ions and a little water pass through the membrane. Chlorine is collected at the anode. The consumption of electricity in this method is the lowest of the three processes. This method is more efficient than the diaphragm method and newly constructed plants exclusively use this method.

Ion exchange membrane process



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

Trend of caustic soda production by process 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

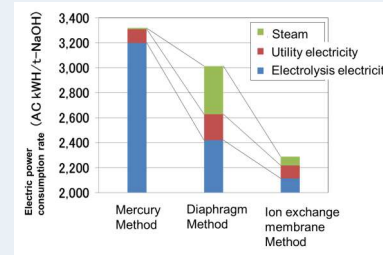
Trend to mercury free technology in Japan

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. In Japan, as a result of effort made by the industry, all mercury cell processes were converted to mercury free process by 1986. Since 1999, ion-exchange membrane process is the only process used in the chlor-alkali facilities of Japan.

Co-Benefits from Conversion

When the Japanese industry started to use the ion-exchange membrane, they encountered issues of high energy cost and poor quality of caustic soda. However, extensive R&D has led to the improvement of electric current efficiency to 96% or more. The total energy consumption is lower by more than 30% compared to the diaphragm or mercury-cell processes, while yielding a better quality (higher purity) product.

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 salt electrolysis plants in over 50 countries all over the world.

Challenges to Technology Adoption

Although ion-exchange membrane processes are more energy conserving and profitable than mercury-cells in the long run, the initial investment cost for the process conversion is high. Therefore, it takes many years for the initial cost to be recovered from the revenue of the converted facility.

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 overall conversion process 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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