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CECRI membrane chlor-alkali electrolysers for conversion of mercury cells and new installations

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CECRI has developed the membrane cell technology based on Nafion membrane, catalytic anode and cathode developed by this institute. This paper discusses the effect of the configuration of electrode base, like perforated, expanded, or finger type and current conductors of baffle, box, channel type etc. The flow pattern of the electrolyte, the effect of multipoint feed on concentration profiles, temperature and hold up volume are some of the important factors considered in this paper. Based on the pilot plant scale (6.0 kA current rating) a power consumption of 2200-2250 kWh/tonne of caustic soda was obtained.

INTRODUCTION

The chlor-alkali industries are forced to look for adopting improved/modern technology due to the energy crisis and spiralling energy costs which account for about 50% of the cost of production. The invention of metal anode 'TSIA' (metal anode developed by this institute) brought down the energy consumption by about 10%. The stringent regulations on the mercury pollution level, due to its poisonous nature, resulted in the development of a new technology. 'The Membrane Cell Process' which produces salt-free caustic, consumes 20-25% less energy compared to conventional processes.

Based on the data collected from the laboratory and bench scale experiments a 6 kA membrane cell (Fig. 1) with metal frames was designed, fabricated and operated. The membranes used were Nafion 901 and Nafion 961.

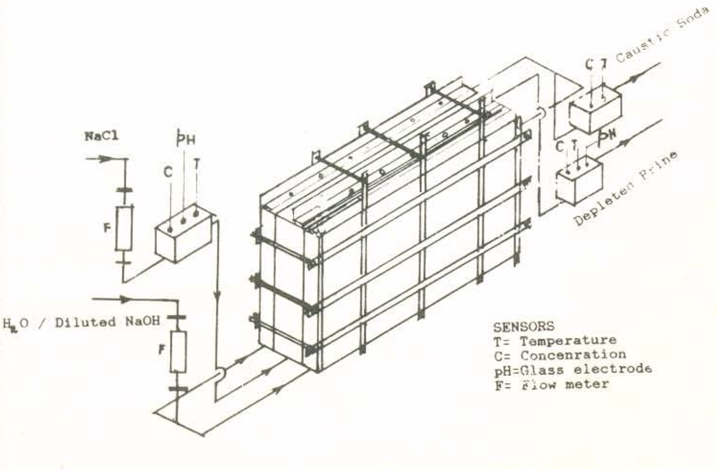

Fig. 1: Membrane cell

EXPERIMENTAL

Electrolyser

The electrolyser has a height to length ratio of 2.5 to 3 with different back volumes. The back volume was determined based on the temperature profile achieved and turbulence created at the electrode surface. The major factor that influences the turbulence was the design of electrodes with different types of current distributors. The current distributors used are channel type, baffle type, and box type. Single nozzle and multiple nozzles were used to feed the electrolyte depending upon the length of electrolyser.

Anode

As the membrane surface was always alkaline and any fluctuation in the pH causes oxygen evolution as a side reaction, the anode needs a catalytic coating which will increase the oxygen overpotential and keep minimum chlorine overpotential. CECRI has developed a three component electrocatalytic coating and adopted it for its membrane cell process. The electrode bases chosen were perforated, rolled expanded sheet, rods arranged at a pitch of 3.0-4.5 mm. Best performances were obtained with the rolled expanded metal base, as it releases the gas bubbles at faster rate.

Cathode

The conventional cathodes, M.S., C.I., S.S. and nickel possess high hydrogen overvoltage ranging from 350-450 mV at a c.d. of 250-300 $mA.cm^{-2}$ at a temperature of 353-358K. This means higher energy consumption. The Raney nickel cathode reduces the hydrogen overpotential to 100-150 mV, but stability during current reversal is very poor and hence the overvoltage increases again. The electrocatalytic coating reduces the overvoltage by about 200-250 mV. The electrocatalytic coating comprises a catalyst and a stabilizer which is an alloy of precious metal group metals over a stainless steel or nickel base. The cathode design is same as that of anode.

RESULTS AND DISCUSSION

Operation and performance

The membrane cell operation involves close control and monitoring of outlet and inlet brine pH, flow of brine and water/dilute caustic, concentration of brine both at inlet and outlet, temperature of feed brine, outlet brine and NaOH. Appropriate sensors and transmitters were incorporated in membrane electrolyser system and connected to computer based datalogger and control unit. The feed brine was saturated NaCl and catholyte feeds were changed from water to dilute NaOH solution of different concentrations. A typical operating performance is given below:

Current rating (kA)	6
Current density ($kA.m^{-2}$)	3.2
No.of electrolysers	2
Anode	TSIA (metal anode)
Cathode	SS with a proprietary coating of CECRI
Membrane	Nafion 961
Brine concentration (gm/l)	300-305
Operating temperature (K)	353-358
Brine pH	2-3
Depleted brine concentration gm/l	200-210
Caustic concentration (%)	30-33
Current efficiency (%)	94-95
Cell voltage (V)	3.1-3.2
Energy consumption (KWh/t)	2185-2250

CONCLUSION

The first indigenous membrane cell was developed at CECRI using all indigenous materials including chelating ion exchange resin except the membrane (E.I. Du Pont of USA). Based on the successful operation of this electrolyser a 72 kA membrane cell with secondary brine purification system was designed and is to be operated shortly in a commercial plant. These cells can easily be adopted to replace the existing mercury as well as diaphragm cells.