Performance Evaluation of Three Kinds of Reverse Osmosis Membranes for Treatment of Ion Exchange Resins Regeneration Wastewater

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Extended Abstract

In this research, we try to use the three kinds of Reverse Osmosis membranes for treatment of ion exchange resins regeneration wastewater, which currently this wastewater is discharged to evaporation lagoons after neutralization. The common methods used for the disposal of these kinds of wastewater in the environment consist of discharge to brackish or saline receiving waters, deep-well injection, and in the case of small facilities, discharge to wastewater collection systems. Despite numerous researches about using membrane processes for industrial wastewater treatment, there was no study or research about using reveres osmosis for treatment of wastewater form ion exchange regeneration process. So, considering the similarities between this kind of wastewater and brackish water or saline water, it has been hypothesized that reverse osmosis has ability to remove dissolved solids from this kind of wastewater; therefore it is necessary to conduct feasibility tests of membrane samples. Feasibility tests can be done by using membrane cell in pilot plant. Thus, we need to provide a pilot plant which has membrane cell and facilities to indicate and control of pressure, temperature and flow to evaluate and investigate the wastewater treatability. Although, at this kind of pilot plant, usually spiral wound RO membrane is used, to achieve the better results with low expenses, the bench scale instruments such as membrane cell were used. In this method, we can use a small sheet of membrane about 10×15 (cm×cm) that sandwiched between two steel part which can tolerate high pressure. The pilot plant designed and set up according to fig.(1).The main parts of pilot plant consist of wastewater tank with 250 liter volume, low pressure pump, cartridge filters, high pressure pump, membrane cell and devices for pressure and temperature control.

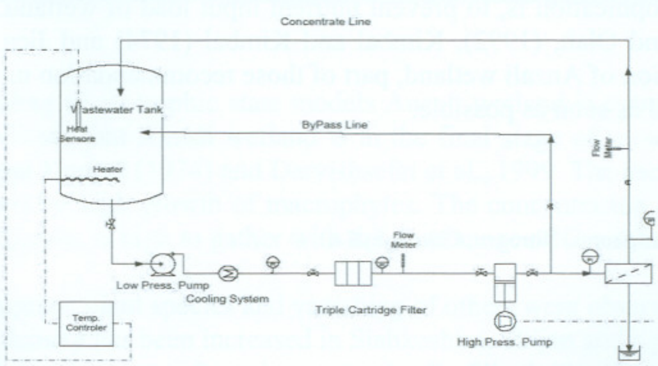

Fig.1: Schematic of RO pilot

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Membrane cell has a key roll in pilot plant. Therefore, at this stage we must adjust pressure and recovery (cross flow velocity) to obtain the most optimum permeate flux with the lowest Electrical Conductivity (EC) and minimum fouling. After entering to the membrane cell, wastewater is divided to two streams: permeate or treated wastewater and concentrate. Permeate is collected in a separate container for volume and EC to be measured at specified time intervals. It is necessary to mention that permeate and concentrate are returned to the wastewater tank to fix wastewater quality during the tests. To obtain precise result pressure and temperature must be controlled. To do so, it is necessary to use frequency inverter for pressure control and temperature controller with cooling system in order to adjust and control of temperature at 30° C. To conduct the study, three kinds of membranes (TORAY TM 810 of Japan , CSM RE-2521 SR of Korea and FILMTEC SW 30- 4040 of USA osmosis membrane), all for seawater, were used which flat sheets of membrane with dimension of 10×15 (cm×cm) prepared from these membranes.
In this study, two variables including temperature and feed water salt concentration are considered constant (temperature equal to 30 °C and EC about 14400 μs/cm); then pressure and recovery have been chosen at three levels and each run of experiment took almost five hours. Therefore, nine experiments have been done for each kind of membrane sample and totally 27 tests have been done to obtain the optimum flux and the minimum EC. The levels are 20, 25 and 30 bar for pressure and for recovery the cross flow velocity 0.27, 0.54 and 0.81 m/s. This means when cross flow velocity increases, the amount of recovery decreases and vice versa. Also when recovery decreases, the chance of fouling is less. To make sure of having the lowest turbidity of wastewater, Silt Density Index (SDI) test has been performed after cartridge filters and most of the times the SDI has been below three. Also to ensure that oxidizing agents are not present in the wastewater, the Oxidation Reduction Potential (ORP) test has been performed and ORP has been always below 175 mV which is suitable for polymer membranes. The pH of all experiments has been adjusted to seven by using sulfuric acid. According to fig.(2) FILMTEC membrane has the highest salt rejection percentage.

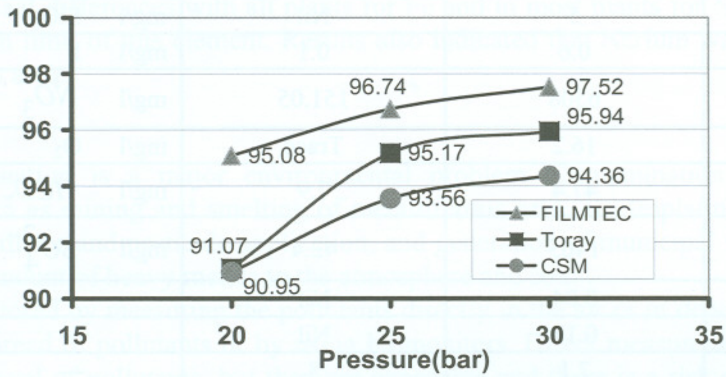

Fig. 2: Salt rejection percentages versus pressure for three kinds of membranes

Therefore, the performance of FILMTEC membrane for treating this kind of wastewater is better than the other membranes but for choosing the best pressure and cross flow velocity, the criteria from manufacturer of the membrane should be taken into account too. For treating this kind of wastewater based on FILMTEC product specification, the permeate flux limit of seawater membrane is 40.5 ($L/m^2.hr$). During this study, EC has been decreased from 14420 ($\mu s/cm$) to about 470 ($\mu s/cm$), under 25 bar pressure and 0.54 m/s cross flow velocity and the permeate flux was 39.1 ($l/m^2.hr$). Table 1 compares analysis of ion exchange regeneration wastewater with permeate which obtained under the condition of 25 bar pressure and 0.54 m/s cross flow velocity for some parameters, and the percentage of dissolved solids removal is nearly 97 which is preferable. Considering the results of treated wastewater, this treated wastewater can be used for irrigation or other purposes.

Table 1: Results of analyzing wastewater from ion exchange regeneration process before and after treatment using Reverse Osmosis

Parameters	Influent Wastewater	Permeate (Treated Wastewater)	Unit		% removal
Sodium	450	8	mg/l	Na^+	98.22
Potassium	36	0.7	mg/l	K^+	98.06
Calcium	439	1.6	mg/l	Ca^{2+}	99.64
Magnesium	202.5	1.2	mg/l	Mg^{2+}	99.40
Barium	0.209	0.004	mg/l	Ba^{2+}	98.09
Strontium	5.52	0.035	mg/l	Sr^{2+}	99.37
Ammonium	1730	28.8	mg/l	NH_4^+	98.34
Total hardness	1930.9	4.1	mg/l	$CaCO_3$	99.79
chloride	616.4	9.1	mg/l	Cl^-	98.52
Phosphate	0.021	Nil	mg/l	PO_4^{3-}	—
Silica	5	Nil	mg/l	SiO_2	—
Fluoride	0.6	0.1	mg/l	F^-	83.33
Nitrate	6508	151.05	mg/l	NO_3^-	97.68
COD	16.2	Trace	mg/l	O_2	—
Bicarbonate	47.4	7.9	mg/l	$HCO_۳^-$	83.33
Sulphate	1405	42.4	mg/l	SO_4^{2-}	96.98
Fe (total)	0.04	Nil	—		—
Copper	0.17	Nil	—		—
pH	7.1	8	—		—
Eclectic Conductivity	14420	470	$\mu S/Cm$		96.74

Key words
Ion Exchange Resin Regeneration Wastewaters , Reverse Osmosis, Membrane Cell, Salt Rejection, Permeate Flux