

Reverse Osmosis Membrane Chlorine Effects Reduction Using Kinetic Degradation Fluxion Media

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Abstract— Nowadays reverse osmosis is one of the most used technologies for water treatment and it is a favored method for potable water production from seawater. However, membrane fouling is a critical problem associated with reverse osmosis (RO) plants, since it has many negative impacts on RO efficiency, effectiveness and operation costs. Moreover, membrane cleaning techniques used to overcome fouling reduce the membrane life time, and sometimes it damage the membrane, also these techniques may create environmental issues related to the waste chemical disposal.

In this study the effectiveness of applying Kinetic Degradation Fluxion media (KDF) as pretreatment step for reducing fouling caused by high dosage of chlorine in RO system was investigated. Each test was carried out using two membranes, reference or control membrane in which feed solution moved directly inside without passing through the KDF media (RO-only), and pretreatment membrane with feed solution passing through KDF media (RO-KDF). The comparison between the two systems in terms of salt rejection and permeate flow indicates that KDF-media effectiveness in Cl_2 removal is high and it can extend the lifetime of RO membrane 3 times at least.

Keywords— RO pretreatment, KDF, Chlorine removal.

I. INTRODUCTION

Chlorination for RO pretreatment has been applied usually where biological fouling prevention is required. Chlorine is added continuously at the intake. A free residual chlorine concentration of 0.5–1.0 mg/L should be maintained through the whole pretreatment line. DE chlorination upstream of the membranes is required, however, to protect the membranes from oxidation. Membrane can withstand short-term exposure to free chlorine; however, its resistance is limited.

Patented KDF is a chemical compound consists of a high-purity alloy of both Cu and Zn, generally KDF is used in a purification system as a profiler, before another, finer stage of filtration, like RO. In KDF media water passes through a

bed of pure KDF, as the water makes contact with the KDF particles the redox reaction takes place, removing such impurities as minerals, metals, dissolved oxygen and organic materials.

II. MATERIALS AND METHODOLOGY

TW30-1812-50 FILMTEC™ RO membrane for home drinking water was used for all experiments. This membrane can work under actually low pressure to reach high salt rejection rate up to at least 99%, and permeate flows up to 50 gallons per day (gpd). Its chlorine tolerance is 0.1 ppm. CuZn filter for drinking water was used as KDF-media. It consists of 11 patented reticulated discs with 2 inch diameter and 0.5 inch height for each disc. The discs are flexible, slightly oversized, lightweight, earth friendly, easy for installation and the porous nature.

Each test was conducted using two membranes, reference or control membrane in which feed water moved directly inside without passing through the KDF media, and pretreatment membrane with feed water passing through KDF media, Fig.1 shows a simplified schematic of the experiment design and layout.

Since the decline in salt rejection and flux rate results from fouling on the membrane, then this decline will be considered as the main RO performance parameter to determine the effect of KDF media on RO membrane fouling reduction thus the effectiveness of KDF media on fouling reduction can be roughly assessed by comparing the salt rejection and permeate flow rate in the absence and in the presence of KDF media. Accurate feed water analysis was conducted before designing the system; this analysis ensures that the potential of different types of fouling like bio fouling and metal fouling is very low.

III. RO MEMBRANE PERFORMANCE PARAMETERS IN CHLORINE EXPERIMENTS

The chlorine experiments was carried out in the period from 22/7/2015 to 8/3/2016, highly chlorinated solution with

5mg/l concentration of chlorine was used for feeding the systems.

3.1 Salt rejection

a. RO-only salt rejection

73.7% was the minimum recorded salt rejection for RO-only system; logically it was obtained with the end of the experiment in the 41th running hour as more chlorinated feed solution contacted with the membrane, in the initial hours of running the salt rejection reached 98.6% as a maximum value, salt rejection was slightly reduced during the first 16 running hours as membrane shows some resistance to short-term attack by chlorine as in fig.2 then the salt rejection was continuously decreased due to the continuous oxidation by chlorine, 15% reduction in salt rejection is a fouling indicator therefore it was supposed that fouling was occurred in RO-only system within the 41th running hours the salt rejection was 73.7% with 26.3% reduction.

b. RO-KDF salt rejection

The RO-KDF system was running for the first 23 hours with the absolutely maximum value of the salt rejection which was between 98% and 98.8% as shown in fig.2, after 34 running hours a slight change in salt rejection occurred so it became 97.1 % which is still considered as a very high salt rejection value. During the last 7 running hours the salt rejection was reduced to 95.8% which was the minimum measured value for salt rejection in RO-KDF system. For salt rejection any value greater than 90% can be considered as high therefore salt rejection level in RO-KDF system kept high after 41 running hours with 5mg/l chlorine concentration.

The reduction rate of salt rejection was increased as chlorine removal by KDF media decreased thus the membrane attacked by more chlorine, as shown in fig.4 the initial chlorine removal by KDF media was 100%, then it began decreasing. From the 17th running hour the chlorine concentration in the feed solution filtered by KDF media exceeded the allowable limit (1ppm), and it was increased as running hours increased resulting in higher reduction rate in salt rejection.

3.2 Permeate flow

RO permeate is a function of temperature, generally permeate flow increase as temperature increase, the experiments were carried out in range of temperature from 12.2°C to 28.7°C. Typical permeate flow at 60psig is plotted to show the proper permeate flow at each temperature degree according to company recommendation.

a. RO-only permeate flow

As shown in fig.3 the minimum difference in permeate flow of RO and the typical permeate flow was 0 at the first running hour, while the maximum difference was 2L in the 5 last running hours, with higher permeate flow produced by the RO-only system than the recommended one because the pores of the RO membrane were enlarged by the oxidative degradation of polyamide RO membranes leading to more permeate flow passed through the membrane. The difference is increased as more chlorinated feed solution was filtered by the RO membrane.

b. RO-KDF permeate flow

As shown in fig.3 the difference in permeate flow of RO-KDF and the typical permeate flow is less than 1L for all the running period. The maximum difference was 0.8L this value was measured 2 times in the 9th and 8th running hour. The difference was not regular so the permeate flow of RO-KDF may be more or less than the recommended one.

3.3 Chlorine removal by KDF

KDF redox media is unique combination of copper and zinc that creates an electro-chemical reaction. During this reaction, electrons are transferred between molecules, and new elements are created. Some harmful contaminants are changed into harmless components. Free chlorine is changed into benign, water-soluble chloride, which is then carried harmlessly through the water supply. After chlorinated feed solution is filtered by KDF media EC is slightly increased due to the transformation of Cl₂ to Cl⁻.

The chlorine removal by KDF media was 100% for the first 13 running hours then it decreased to 73% after 41 running hours, the RO-KDF membrane was exposed to 1.66mg/l of Cl₂ as a maximum dosage and this value is actually greater than the allowed chlorine tolerance for RO membrane, but the maximum concentration of chlorine in the final permeate flow was less than 0.8 mg/l and it is accepted according to World Health Organization (WHO) for drinking water. Cl₂ concentration in the permeate flow in RO-only exceeded the limited value after 7 running hour only as in fig.4, the Cl₂ rejection by RO-only membrane almost stopped by the 25th running hour so the concentration of Cl₂ in the permeate flow was nearly equal to that in the feed solution. From the 11 discs of the KDF media only one was oxidized by chlorine during the 41 running hours with 1237L of high chlorinated feed solution passed through it.

IV. TABLES AND FIGURES

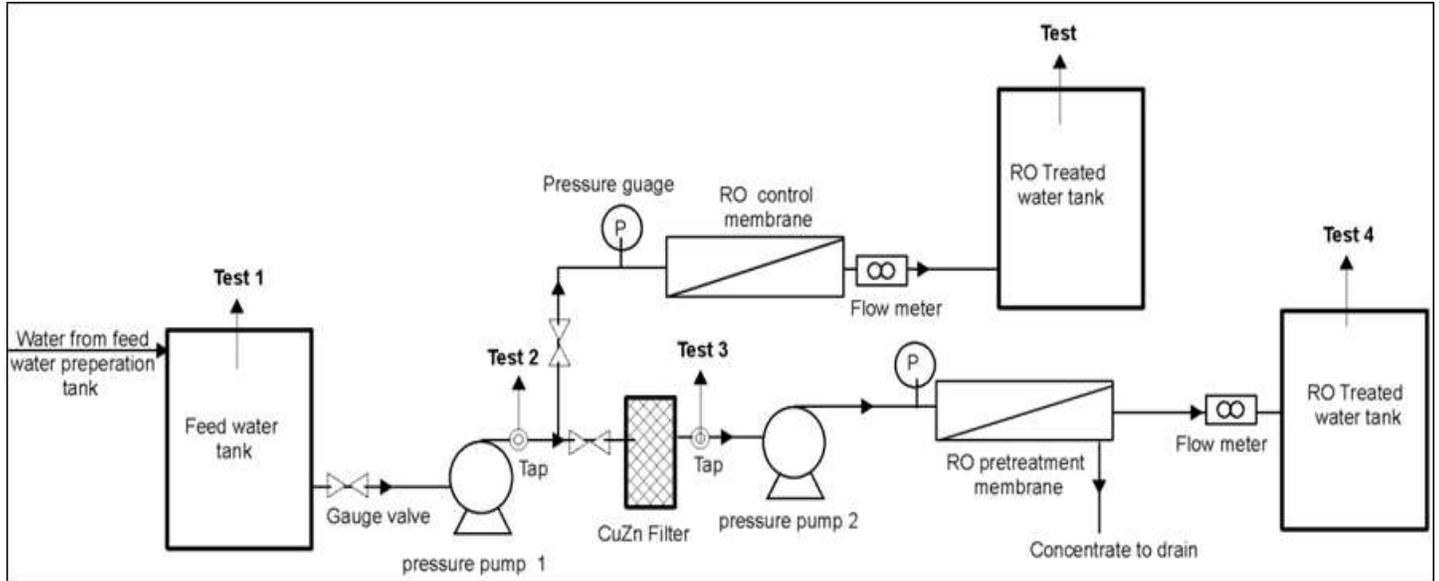


Fig. 1: Experiments schematic design for RO system.

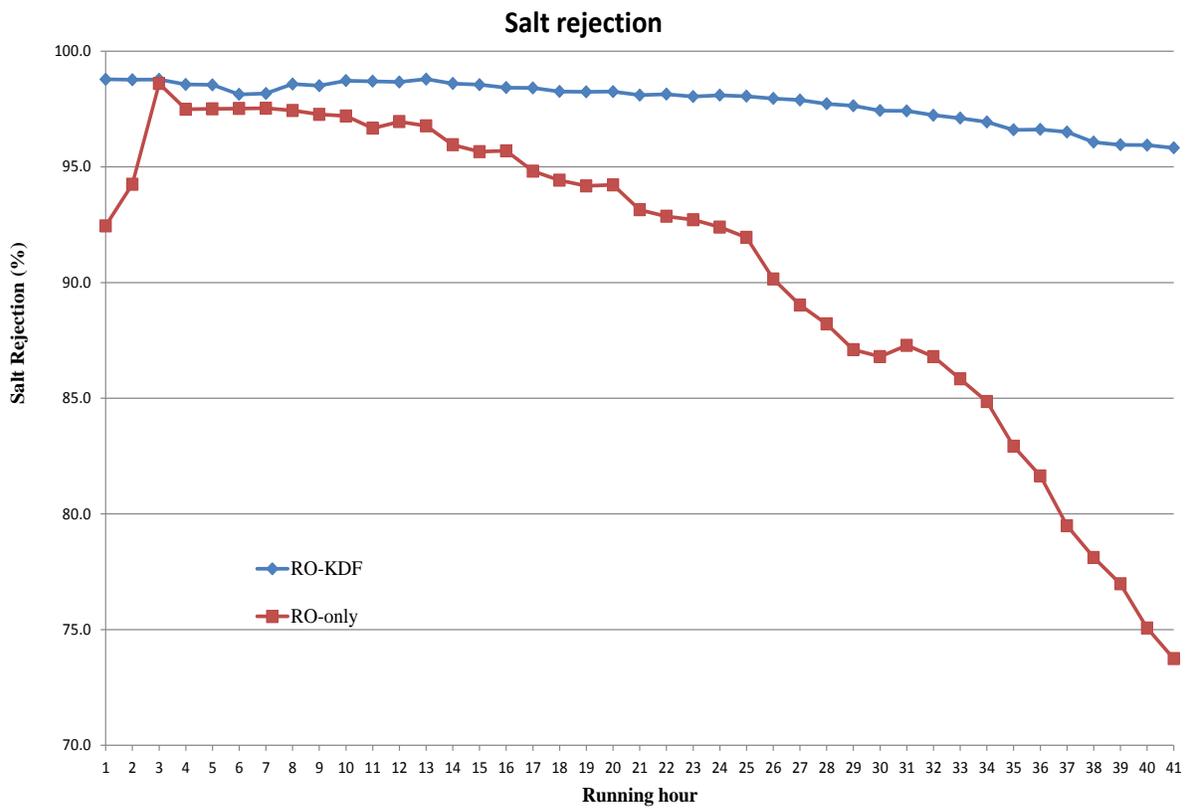


Fig.2: Salt rejection obtained by RO-only and RO-KDF systems.

considered as effective pretreatment step in RO system for chlorine removal and KDF media capability in Cl₂ removal is very high.

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