Challenges and Advancements for Ultra High Brine Recovery

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EXTENDED ABSTRACT

I. INTRODUCTION

Two key trends have been emerging over the past few years, one is that natural resources continue to become more scarce and industrial waste discharges are having a significant negative impact on available fresh water sources. These two factors have naturally led to the growing interest in more economical treatment processes to hyper concentrate mineral rich waters. These process can are called by terms such as minimum liquid discharge (MLD), zero liquid discharge (ZLD) of saline brine recovery (SBR). In principal, they all have a common theme of concentrating mineral rich waters to near saturation limits, then treatment by crystallization processes to recover dry mineral solids.

The conventional approach to these applications includes softening, initial concentration with nanofiltration (NF) and/or reverse osmosis (RO), super concentration with evaporation and solids generation through the use of crystallization process. Although this process is very robust and well proven, it is also energy and capital intensive. To make these new MLD, ZLD and SBR process more accessible to industry, improved treatment processes utilizing new low energy alternative processes are being developed and demonstrated.

This paper will look at new membrane technology being developed to selective separate certain salts and minerals, low fouling, high pressure membranes and ultra-high pressure membranes for high recovery of water from mineral rich brines. Pilot data has shown that these new products can more effectively reduce the need for expensive evaporation processes and can selectively separate minerals into different streams to be more effectively utilized or treated. The paper will also show design simulations of various options to carry out the treatment, as well as the economic analysis of these options.

II. CASE STUDIES FOR APPLICATION OF NEW MEMBRANE TECHNOLOGY

In particular, three case studies will be examined which show how new membrane technology can improve the concentration of mineral rich process waters and wastewaters. Although the treatment of these streams has proven to be challenging, the pilot demonstration led to suitable operation conditions which allowed for stable operation and eventual commercialization.

Case 1: Minimization of Cooling Tower Blowdown Wastewater
In this case, the cooling tower blow down from a remote power generation facility needs to be treated to very high recovery to reduce excessive discharge to a holding pond. In this example, the process selected consisted of unique chemical softening, ceramic ultrafiltration, low fouling high pressure RO, ultra high pressure RO, and evaporation. The pilot test at site showed that the water was difficult to treat and led to high fouling rates on the UF and RO membranes. Final operation conditions we identified which resulted in stable operation of the RO membranes. The treatment scheme is shown in Figure 1. Finally, the process demonstrated that the RO membranes could concentrate the wastewater from 1500 mg/l TDS up to 120,000 mg/l TDS, or 98% recovery. The final brine flow was within the limits of operation for the evaporation pond at site.

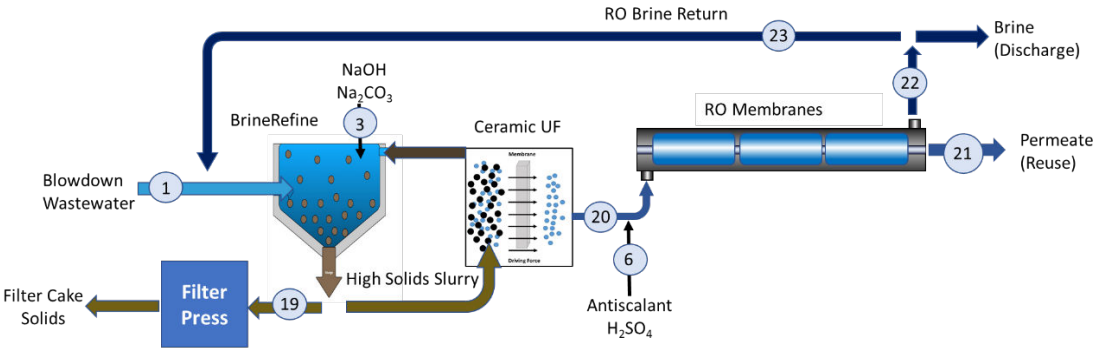

Figure 1 Overview of pilot treatment process to concentrate the CTB wastewater.

Case 2: Treatment of Industrial Textile Wastewater

Many industries have increased restrictions on the wastewater that they can discharge, due to the presence of high levels of organics or minerals. This issue is very acute in India, where textile industrial plants have been forced to implement ZLD in order to recovery the quality of rivers such as the Ganges. Many textile plants have elected to send their wastewaters to common effluent treatment plants (CETP), where more extensive water treatment processes have been used. In this case, a pilot was operated to show the use of ultra-high pressure membranes which were used to treat a saline RO brine which contained 93,000 mg/l TDS. The UHPRO was operated at 20% recover to further minimize the brine concentration. The UHPRO was run at up to 100 bar at a temperature of 35 C. Although the fouling rate was significant due to the high organic load, the membranes were able to achieve consistent performance. The operating pressures and normalized salt passage of the UHPRO membranes is shown in Figure 2.

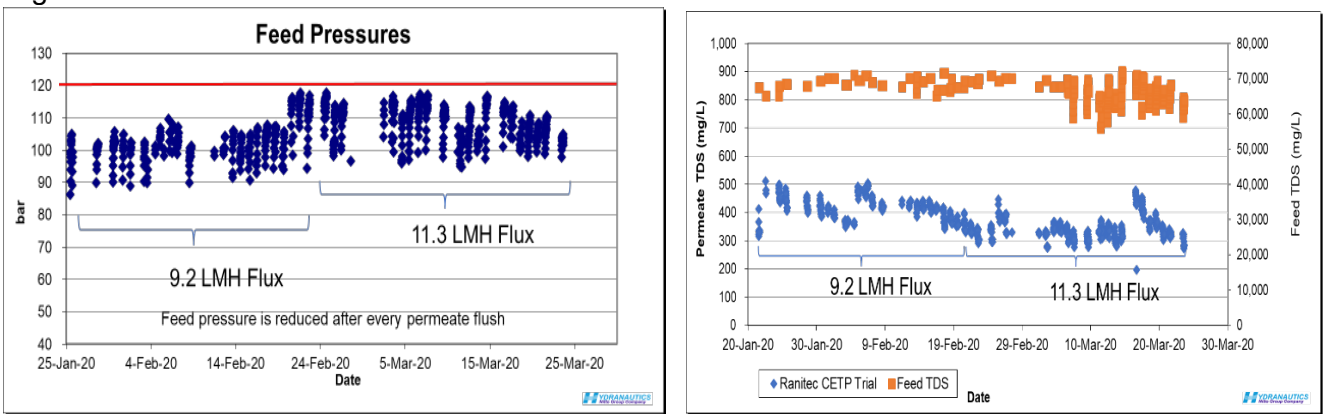

Figure 2 Operation data from UHPRO treating concentrated textile wastewater

Case 3: Softening and Ultra High Concentration of Seawater

Through a cooperative effort with DTRI, FEDCO and others, a multi-membrane treatment membrrane process has been piloted to first remove hardness and sulfate from seawater from the Arabian Gulf. This has a two-fold approach of recovering valuable multivalent magnesium ions for augmentation of desalinated water and secondly, to maximize sodium and chloride in the feed to the SWRO process. While this water will be primarily used for potable water production, the resulting RO brine will be highly concentrated for use as feed in a chlor alkalai plant. Data will be presented to show how new NF membranes can achieve low values of magnesium in the permeate, which is fed to SWRO membranes. The concentrate from the SWRO membranes was treated by UHPRO membranes to further concentrate the SWRO brine. The process design of this step is shown in Figure 3.

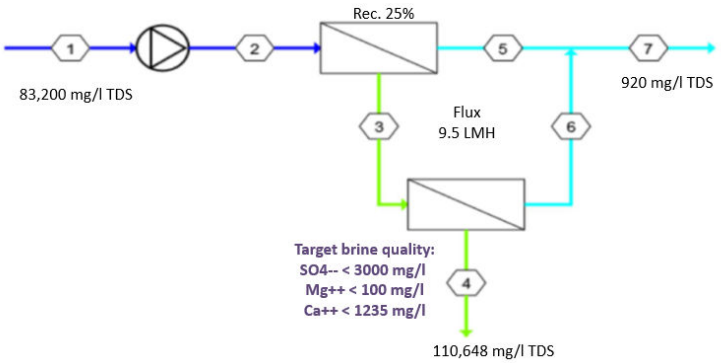

Figure 3 Operation scheme for UHPRO treating SWRO Brine

This was operated for an extended period with stable results in which the SWRO brine was concentrated from 83,000 mg/l TDS to over 110,000 mg/l TDS. This UHPRO brine was then treated by FO or NF processes to reach 200k-220k mg/l TDS. One of the options to treat this brine is high pressure NF. Examples of operation data for new HP-NF membranes will be presented. The HP-NF membranes have relatively low rejection of NaCl, but the benefit is that the brine can be concentrated at relatively normal pressures seen in SWRO (70-80 bar). The downside of this treatment is the high salinity of the permeate needs to be recycled and retreated by the SWRO membranes. This paper will make an economic comparison of various process treatment options, including SWRO→ UHPRO → HP-NF as well as a new concept of SWRO → multistage HP-NF.

III. CONCLUSIONS

We see from these various case studies the multiple membrane products can be used in innovative high recovery processes to minimize waste stream flows, or to concentrate and purify valuable minerals.