Comparison of Polymeric and Ceramic MF/UF Membranes for the Treatments of produced Water

Abstract

In recent years, the extraction of unconventional resources has driven an immediate increase in the development of oil and gas (O&G) production. Hydraulic fracturing is the key technology that has enabled the extraction of unconventional resources. The management of hydraulic fracturing flowback and produced water is a major challenge for unconventional O&G exploration and production. The expedited rate of hydraulic fracturing development coupled with increased demand for fresh water, water scarcity, limited disposal options, and concern of environmental impacts has elevated the O&G industry to minimize fresh water consumption and increase their reuse application. Ceramic membranes have been rapidly emerging in water and wastewater treatment as an alternative to polymeric membranes, but yet little information on their performance and fouling mechanism is available. The purpose of this study was to design and build a MF ceramic membrane system in order to evaluate the fouling characteristics and effluent quality of ceramic membrane and compare it with UF polymeric membrane in produced water treatment

An inside-out tubular mono channel ceramic membrane with a nominal pore size of 0.2 µm was chosen for the designed system due to its ability to operate at higher flux. The system was operated at three different cross flow velocities (CFV) of 0.2, 0.5, and 1.0. Instead of using backwashing, backpulsing was evaluated for fouling mitigation. With adjustable duration, backpulsing delivered high pressure (>100 psi) burst of reversed permeate to the membrane in an adjustable time interval. The performance of the ceramic membrane system was evaluated based on membrane fouling mitigation and treated water quality.

Finding results for the ceramic membrane indicated that increasing the CFV from 0.2 to 0.5 and to 1.0 at two different flux (40 and 60 LMH) lowered the total fouling index (TFI). The hydraulic irreversible fouling index (HIFI) appeared to decrease with increasing the CFV at 40 LMH, however, this was not observed at 60 LMH where HIFI showed an increase with increasing of the CFV which could be possibly due fewer backpulses for the same accumulative volume at the higher flux. The operation at 80 LMH for all three CFV showed a rapid increase in both TFI and HIFI and reached the critical flux for CFV 0.2 and 1.0 m/s.

The results of the comparison between ceramic and polymeric polyvinylidene fluoride (PVDF) membrane with the pore size of 0.03 μm at CFV 0.2 m/s and flux of 40 LMH indicated that the ceramic membrane had a lower TFI than the polymeric membrane. The polymeric membrane, however, appeared to have a significantly lower HIFI than the ceramic membrane. This could possibly be due to weaker interaction of the foulant with the polymeric membrane since it had a smaller pore size than ceramic membrane. Another plausible explanation is that backwashing was a more effective cleaning method compared to backpulsing.