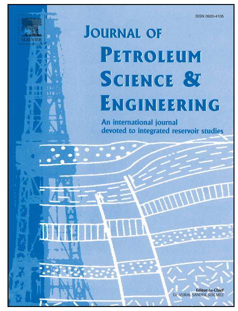
Accepted Manuscript



Cleaning of ceramic membranes for produced water filtration

T. Zsirai, H. Qiblawey, P. Buzatu, M. Al-Marri, S.J. Judd

PII: S0920-4105(18)30222-5

DOI: 10.1016/j.petrol.2018.03.036

Reference: PETROL 4777

To appear in: *Journal of Petroleum Science and Engineering*

Received Date: 28 May 2017

Revised Date: 5 March 2018

Accepted Date: 6 March 2018

Cleaning of ceramic membranes for produced water filtration

Zsirai, T.[1], Qiblawey, H.[2], Buzatu, P.[1], Al-Marri, M.[1,2], and Judd, S.J.[1,3]
[1]Gas Processing Center, Qatar University; [2]Department of Chemical Engineering, Qatar University. [3]Cranfield Water Science Institute, Cranfield University.

Abstract

The application of ceramic microfiltration membranes to the tertiary treatment of produced water from an Arabian Gulf oilfield has been studied using a dedicated pilot plant. Studies were based on a previously published protocol in which the retentate stream was recycled so as to successively increase the feed concentration throughout the experimental run. Chemical cleaning in place (CIP) was applied between each run and the flux and permeability recovery recorded for various cleaning protocols studied, the CIP being based on the combination of caustic soda (NaOH) and citric acid. Surface analysis of the membrane, and specifically its hydrophilicity, was also conducted.

Results indicated the main influencing factor on permeability recovery from the CIP to be the employment of backflushing during the CIP itself. A final flux of 700 L m^{-2} h^{-1} was sustained through the application of 6 wt% NaOH with 6 wt% citric acid combined with backflushing at approximately twice the rate of the filtration cycle flux. A consideration of the impact of this flux value on the viability of two commercially-available ceramic membrane technologies indicated the footprint incurred to be slightly lower than that of the upstream induced gas flotation technology and corroborated a previously published estimate. The flux was sustained despite surface analysis indicating a loss of the innate hydrophilicity of the ceramic membrane.

Keywords *Produced water; ceramic membranes; chemical cleaning; footprint; flux.*

1 Introduction

Produced water (PW) generated from oil exploration requires rigorous removal of suspended matter (free oil and particulate solids) as tertiary treatment (downstream of hydrocyclone and gas flotation) if it is to be desalinated for reuse (Alzahrani et al, 2014) or re-injected into low-permeability reservoirs (Judd et al, 2014; Xu et al, 2016). The application of membrane technology for this duty has been recently reviewed (Munirasu, 2016; Dickhout et al, 2017), and the option of ceramic membrane filtration widely explored (Ebrahimi et al, 2010; Guirgis et al, 2015; Weschenfelder, 2015, 2016).

The viability of membrane processes generally is largely dependent on sustaining a high membrane flux to minimise the process footprint, a particularly important attribute on offshore oil platforms where available space is at a premium. The use of silicon carbide (SiC) ceramic membranes for this duty has been demonstrated to provide a reliably high treated water quality (6.3 - 7.6 mg/L oil and grease (O&G), 4 - 8 NTU turbidity) for microfiltration (MF, pore size 2 μm) and ultrafiltration (UF, pore size 0.04 μm) membranes based on recent pilot-scale studies (Zsirai et al, 2016) using real PW from an offshore oil platform. The larger-pore MF membrane was shown to provide a significantly higher flux than the UF membrane, but was also subject to greater flux (and permeability) decline. Moreover, it was noted that there was a marked deterioration in both permeate water quality and permeability with successive experimental runs on the chemically-cleaned membrane. The work