STATISTICAL ANALYSIS OF POLYMER-BASED GEL FOR WATER SHUT-OFF TREATMENT IN OILFIELD APPLICATION

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by

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LIST OF ABBREVIATION

ANOVA	Analysis of Variance
AP	Alkylphenols
BBD	Box-Behnken Design
Cr(III)	Chromium (III) Acetate
DOE	Design of Experiment
EOR	Enhanced Oil Recovery
FTIR	Fourier Transform Infrared
GG	Guar gum
HAP	Hydrophobically Associating Polymer
HEMC	Hydroxyethyl Methylcellulose
HPAM	Hydrolyzed Polyacrylamide
HPMC	Hydroxypropyl Methylcellulose
NORM	Natural Occurring Radioactive Material
PAA	Polyacrylacid
PAH	Polycyclic Aromatic Hydrocarbons
PAN	Polyacrylnitrile
PEI	Polyethyleneimine
PHPA	Partially Hydrolyzed Polyacrylamide
PVA	Polyvinyl Alcohol
PVP	Polyvinyl Pyrrolidone

RSM	Response Surface Methodology
TDS	Total Dissolved Solid
XC	Xanthan gum and Cr(III) polymer gel
XCG	Xanthan gum, Cr(III) and Guar gum polymer gel
XCH	Xanthan gum, Cr(III) and HPMC polymer gel
XCP	Xanthan gum, Cr(III) and PVP polymer gel
XG	Xanthan gum

ANALISIS STATISTIK GEL BERASASKAN POLIMER UNTUK RAWATAN MENGHALANG ALIRAN AIR DI DALAM APLIKASI MEDAN MINYAK

ABSTRAK

Air yang dihasilkan di telaga minyak akan mengurangkan pengeluaran minyak dan gas dan ia merupakan sisa terbesar di dalam industri minyak dan gas. Untuk mengurangkan pengeluaran air yang tidak diingini, rawatan kimia menggunakan polimer adalah fokus dalam kajian ini. Biopolimer gam xanthan dan bahan sambungan silang, kromium (III) asetat digunakan dalam kerja-kerja penyelidikan ini. Penambahan bahan tambah polimer seperti gam guar (GG), Hydroxypropyl methylcellulose (HPMC) dan polyvinyl pyrrolidone (PVP) juga digunakan dalam kajian ini. Salah satu teknik statistik yang digunakan adalah kaedah permukaan respons (RSM), penggunaan Rekabentuk Eksperimen (DOE). Masa sasaran untuk pengegelan fasa gel mengalir adalah antara 180 minit hingga 240 minit dan masa yang pengegelan fasa gel menjadi pepejal adalah antara 1000 minit hingga 1440 minit. Larutan xanthan-kromium (XC) menjadi gel mengalir pada 180 minit dan gel pepejal pada 1265 minit. Untuk larutan XCG dan XCH, gel mengalir berlaku pada masa 240 minit dan larutan XCP pada 235 minit. Masa gel pepejal bagi larutan XCG, XCH, dan XCP masing-masing berlaku pada 1015 minit, 1440 minit dan 1410 minit. XCP mempunyai rintangan yang lebih baik terhadap larutan air garam dimana perubahan dapat dilihat selepas 80 hari. Sementara itu, larutan XC berubah apabila bertemu dengan air laut sintetik selepas 75 hari. Kajian percirian terhadap larutan menujukkan kelikatan berkurangan apabila suhu bertambah, manakala kelikatan semingkat apabila masa berlalu.

STATISTICAL ANALYSIS OF POLYMER-BASED GEL FOR WATER SHUT-OFF TREATMENT IN OILFIELD APPLICATION

ABSTRACT

Produced water decreases the production of oil and gas and it is currently the largest waste stream in oil and gas industry. In order to reduce the amount of produced water, a chemical treatment using polymers is the focus in this research. Biopolymer xanthan gum (XG) and cross-linker, chromium (III) acetate (Cr(III)) are used in this research work. Polymer additives such as guar gum (GG), Hydroxypropyl methylcellulose (HPMC) and polyvinyl pyrrolidone (PVP) are also used in this research work. One of the statistical techniques used is response surface methodology (RSM), the application of Design of Experiment (DOE). The targeted gelation time of flowing gel phase is between 180 minutes to 240 minutes and the gelation time of solid gel phase is within 1000 minutes to 1440 minutes. Xanthan-chromium (XC) solution form flowing gel at 180 minutes and solid gel at 1265 minutes. For XCG and XCH solutions, the flowing gel phase is formed at 240 minutes and XCP solution form at 235 minutes. Solid gel phase for XCG, XCH and XCP solutions is formed at 1015 minutes, 1440 minutes and 1410 minutes respectively. XCP have better resistance towards brine solutions as the changes can be seen after 80 days. Meanwhile, XC solution changes when meet with synthetic seawater after 75 days. Characterization studies of the solutions shows that the viscosity decreases as the temperature increases, meanwhile the viscosity increases as the time passes by.

CHAPTER ONE

INTRODUCTION

1.1 Produced Water

Produced water is an oilfield wastewater that generated in large volumes either from onshore or offshore oil and gas production (Emam, *et al.*, 2014). Larger amounts of water are produced from oil producer because of water injection upon maturity of the wells. More than 40% of the produced water is discharged to the environment and globally, approximately 250 million barrels of water are produced daily from both oil and gas fields (Igunnu and Chen, 2012). An estimated 667 million metric tons of produced water were discharged throughout the world in 2003 including 21.1 million tons offshore waters in North America (Neff, *et al.*, 2011). The produced water generated roughly in the range of 15 to 20 billion barrels each year and it produces a volume of 1.7 to 2.3 billion gallons water per day in the United State (Clark and Veil, 2009).

Produced water is a mixture of different organic and inorganic materials (Ahmadun, *et al.*, 2009). The composition is complex and can be comprised of several thousand compounds that varies in concentration between wells and over the lifetime of a production well (Bakke, *et al*., 2013). Major compounds of produced water include dissolved and dispersed oil compounds, dissolved formation minerals, chemical compounds, production solids which include formation solids and dissolved gases (Ahmadun, *et al*, 2009). Other than that, large amounts of organic materials, particles, inorganic salts and low molecular weight organic acids like acetic acid and also a high level of sulfur and sulfide can be found in produced water

(Bakke, *et al.*, 2013). Normally, produced water derived from gas wells contain several times greater concentration of metals than that derived from oil wells (Emam, *et al.*, 2014).

The production of produced water needs to be reduced or control because its limits the productive life of the oil and gas wells. Other than that, produced water reduces the production of oil and causes several problems such as corrosion of tubular, hydrostatic loading and also fines migration (Badaiwi, *et al.*, 2009). Large amount of produced water results in more complex water-oil separation, rapid corrosion of production well equipment and rapid decline in hydrocarbon recovery. Untreated discharged of produced water may be harmful to the surrounding environment because it contains elevated levels of dissolved ions (salts), hydrocarbons and trace elements (Emam, *et al.*, 2014).

1.1 Water Shut-off Treatment

In order to reduce the production of water, certain treatment needs to be conducted. The process which blocks the water to reach and enter the production well is called water shut-off treatment. Water shut-off treatment consists of mechanical and chemical methods that practically used in the oilfield application. Mechanical methods include drilling horizontal, multi-lateral wells, placing a liner to block water production and downhole separation equipment (Simjoo, *et al.*, 2007). Mechanical methods are usually expensive.

Candidate selection, identification of the source water, proper choice of the chemical system and placement of chemicals into the target zone are several factors that determine the success of a chemical treatment in the field (Simjoo, *et al.*, 2007).