

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



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**Department of Petroleum Engineering**

**Simulation Study of Surfactant and Polymer  
Flooding to Enhance Oil Recovery . A Case  
Study of Abu Gabra 6 Reservoir**

مر بالمحفزات السطحية والبوليمر لتعزيز

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**A Thesis Submitted in Partial Fulfillments for The  
Degree of M.Sc. in Petroleum Engineering**

**{Reservoir Engineering}**

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**September**

**2014**

# الاستهلال

(وَمَا أُوتِيتُمْ مِنَ الْعِلْمِ إِلَّا  
قَلِيلًا)

دق الله العظيم

# **Dedication**

**To my lovely parents who are  
teaching me the meaning of love**

**To my lovely kids...**

**(Abdalrahman) and (Aya)**

**To my husband.....**

**To my sisters and brothers.....**

**To my teachers and colleagues.....**

# **Acknowledgment**

**I would like to express my sincere  
appreciation to my**

**Advisor:**

**Dr./Elradi Abaas**

**I want to present especially thanks to:**

**Eng./Albadi Omer Babiker**

**He stood beside me and provided a  
good support to me.**

# Abstract

Primary and Secondary Recovery techniques together are able to recover only about 5-40% of oil from the reservoir. This leaves a significant amount of oil remaining in the reservoir. The residual oil left after the water flooding is either from water swept part or area by-passed by the water flooding. The by-passed residual oil has a high interfacial tension with the water. One way of recovering this capillary trapped oil is by flooding the reservoir with chemicals (surfactant, alkali-surfactant (AS), surfactant-polymer (SP), or alkaline-surfactant-polymer (ASP)).

The Neem field which is the case for this study having approximately current recovery factor of 8.2%. The oil production has peaked in 2006 and is now declining. The pockets of residual oil saturation are still trapped in the reservoir especially in Abu Gabra formations. The water flooding alone cannot recover capillary trapped oil pockets efficiently, thus requires enhanced oil recovery techniques. The EOR screening criteria suggested by Taber et.al was applied to Neem field Abu Gabra -6 reservoir in order to come up with the right EOR method that would reduce residual oil saturation to the minimum. Four EOR cases such as base case, water flooding case, water alternative gas case and surfactant /polymer flooding case, were simulated for the AbuGabra-6(AG-6).

The main objective of this study was to perform a comparative simulation study to evaluate the effectiveness of these chemical methods compared to conventional water flooding method in terms of recovery factor. One of the flooding methods will be chosen to for AG-6 based on the recovery factor.

Three cases were run using Eclipse 100, black oil simulator, and a correlation data for EOR PVT Model. From simulation results, base case gives 8.2%, WI 51%, WAG 52% and SP flooding was found to be better than other cases in terms of recovery factor it gives 57% for AG-6. It is recommended that right surfactant and polymer structure that would be compatible with fluid and rock properties of AG-6 to be developed in the laboratory. It is also important that up-scaling the appropriate laboratory identified chemicals to a field-scale usage be done correctly. The timing of SP injection into AG-6 is also recommended to be early in the life of the field because injection of SP at a later time might not lead to best possible oil recovery.

تقنيات الاستخلاص الأولى والثانوي قادرة على استخلاص بنسبة مئوية ما بين 5-40% من النفط في الممكن، مما يؤدي إلى متبقي ليس بالكمية التي يمكن إهمالها. وكذلك النفط المتبقي بعد استخدام الغمر بالماء إما من الماء المتبقي بعد المسح أو من ممر الماء خلال الفراغات مما يؤدي إلى حبس الزيت، وهذا الأخير له قوة توتر سطحي كبيرة مع الماء و هناك طريقة واحدة لمعالجة قوة التوتر السطحي الكبيرة و هي غمر الممكن باستخدام الغمر بالكيمياءيات مثل (المحفزات السطحية، القلوي والمحفز السطحي، المحفز السطحي والبوليمر، أو القلوي والمحفز السطحي والبوليمر معا). حقل نيم وهو موضوع الدراسة يعطى قيمة 0.8% كمعامل استخلاص . بدأ الإنتاج منه في عام 2006 م وآلآن هناك تدنى في الإنتاج هناك جيوب من تشبع الزيت الحبيس ما زالت محبوسة وبالأخص في تركيب أبو جابرة ممكن أبو جابرة -6. الغمر بالماء وحده لا يمكنه استخلاص الزيت الحبيس بالخاصية الشعرية بكفاءة لذا احتجنا إلى استخدام تقنيات الاستخلاص المحسن للنفط. معيارية الاستخلاص المحسن للنفط التي اقترحت من قبل تاير وأخرون هي التي طبقت على حقل نيم ممكن أبو جابرة -6 للحصول على اصح وأفضل طريقة من طرق الاستخلاص المحسن والتي تقلل من تشبع الزيت إلى اقل حد ممكن. اربعة من حالات الاستخلاص المحسن استخدمت وهي الحالة الأساسية، الغمر بالماء، وحقن الماء والغاز التبادلي، والغمر بالمحفزات السطحية والبوليمر وكلها قد تمت المحاكاة الحاسوبية لها لممكن أبو جابرة. الهدف الأساسي لهذه الدراسة هو عمل محاكاة لكل حالة ومقارنتهم لتقييم فعالية كل منها من منطلق معامل الاستخلاص. بعد ذلك احد هذه الطرق سيعتمد لممكن أبو جابرة اعتمادا على معامل باستخدام محاكي الزيت الأسود ، Eclipse 100 الاستخلاص. اربعة حالات قد حوكت باستخدام برنامج ومعلومات الضغط والحجم ودرجة الحرارة لعمليات الاستخلاص المحسن قد تم عمل مضاهاة لها لعدم توفر من نتائج المحاكاة وجد أن الحالة الاساسية اعطت معامل استخلاص 8.2%، الغمر معلومات معملية أكيدة. بالماء اعطى 51%، وحقن الماء والغاز التبادلي اعطى 52% و الغمر باستخدام المحفزات السطحية والبوليمر قد أعطى معامل استخلاص 57% لممكن أبو جابرة -6. وقد نصح بأن الاختيار الأفضل للمحفزات السطحية و البوليمر لابد أن يتناسب مع خواص المائع والصخر لكي يتم تطويرها معمليا. ومن المهم أيضا توسيع نطاق النتائج العملية لتشمل الحقل بأكمله لكي يجرى التقييم صحيحا . كذلك قد نصح بابتداء توقيت حقن المحفزات والبوليمر مبكرا مع عمر الحقل لأنه إذا طبقت متأخرا قد لا يؤدي إلى نتائج ذات فائدة ترجى .

## Nomenclature

**Nomenclature:**

AG	Abu Gabra
AP	Alkaline and Polymer
AP	Alkaline Polymer
API	American Petroleum Institute
ASP	Alkaline Surfactant Polymer
EOR	Enhanced Oil Recovery
GOR	Gas Oil Ratio
IFT	Interfacial Tension
IOR	Improved Oil Recovery
IPV	Inaccessible Pore Volume
M	Mobility Ratio
NPV	Net Present Value
OOIP	Original Oil in Place
PV	Pore Volume
PVT	Pressure Volume Temperature
SP	Surfactant and Polymer
STOOIP	Stock Tank Oil in Place
W	Water
WAG	Water Alternative Gas
WI	Water Injection

**Abbreviation:**

b	Barrel
C	Celsius
Cp	Centi Poise
Ev	Effective Volume
K	Permeability
mD	Milli Darcy

mKB	Meter Kelly Bushing
Nc	Capillary Number
o,g	Oil ,Gas
stb	Stock Tank Barrel
stf	Standard Tank Feet
	Mobility
$\mu$	Fluid Viscosity



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