Sudan University of Science and Technology

College of Graduate Studies

College of Petroleum Engineering and Technology

Petroleum Engineering Department

A Comparison of Relative Permeability between Centrifuge and Unsteady State Experiments Results

(A Case Study - A Sudanese Sandstone Reservoir)

مقارنة نتائج النفاذية النسبية بين نتائج تجارب الطرد المركزي وحالة عدم الاستقرار

(دراسة حالة – مكمن رملي سوداني)

THESIS SUBMITTED IN PARTIAL FULFILMENTS FOR THE DEGREE OF M.Sc IN PETROLEUM ENGINEERING (RESERVOIR)

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الاستهلال

بسم الله الرحمن الرحيم

قال تعالى :

{يا أيها الذين آمنوا انفقوا من طيبات ما كسبتم ومما اخرجنا لكم من الأرض..}

سورة البقرة الآية (267)

Dedication

Every challenging work needs self efforts as well as guidance of elders especially those who were very close to our heart .

My humble effort dedicate to my sweet and loving

Father & Mother

Whose affection ,love ,encouragement and prays of day and night make me able to get such success and honor,

Along with all hard working and respected

Teachers.

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I am also thankful to authority for providing me the information .

Nomenclature

Symbols

g	Gravitational acceleration, cm/s^2
k	Permeability, md
L	Length, m
M	Molecular weight
S_g	Gas saturation, fraction
S_w	Water saturation, fraction
S_o	Oil saturation, fraction
S_{wc}	Connate Water saturation, fraction
S_{oc}	Critical oil saturation, fraction
T	Temperature, C°, F°
V	Volume, cm^3
μ	Viscosity, centipoises (cp)
ρ	Fluid Density, $\frac{gm}{cm^3}$
θ	Angle, degree
φ	Porosity, fraction

Abbreviations

AIME	The American Institute of Mining, Metallurgical and Petroleum Engineers
API	American Petroleum Institute
GOR	Gas-Oil Ratio
ECLIPSE	Simulation Software
EUR	Estimated Ultimate Recovery
FVF	Formation Volume Factor
IMPES	Implicit Pressure-Explicit Saturation
IPR	Inflow performance relationship
IPTC	International Petroleum Technology Conference
MMSTB	Millions of Stock Tank Barrel
OOIP	Original Oil in Place
OWC	Oil-Water Contact
PDE	Partial Differential Equation
QC	Quality Check
RF	Recovery Factor
SCAL	Special Core Analysis Lab
SPE	Society of Petroleum Engineers
STB	Stock Tank Barrel
JBN	Johnson, Baossler and Neuman
USMB	U.S. Bureau of Mines

ABSTRACT

Relative Permeability is the ratio of the effective permeability for a particular fluid to reference or base permeability of the rock . It is one of the most fundamental rock-fluid characteristics in multi-phase flow, critical influencing both the initial reservoir fluids distribution and the dynamic process of oil recovery.

The determination of relative permeability requires laboratory experiments, which are expensive and time consuming .Assuming that core material is available, typically a limited number of core plugs are consider for testing. There is uncertainty in the results from two different methods of relative permeability in the same formation .

The primary objective of this study was measuring and normalize the relative permeability for an oil/brine in a sandstone core using the Unsteady state and Centrifuge methods. Investigation and compression of the relative permeability curves for the two methods.

Measure and comprise of sandstone core samples using SCAL data. Four samples of SCAL data were available for this study from the same formation two of them is Unsteady state relative permeability and the other two for Centrifuge capillary pressure.

The final comparison between centrifuge relative permeability curves and unsteady state relative permeability curves showed a very good correlation for the non wetting phase curves, but completely different shapes for the wetting phase curves.

تجريد

النفاذية النسبية هي نسبة بين النفاذية الفعالة إلى النفاذية المطلقة، والتي تعبر بتروفيزيائيًا بالجريان النسبي لطور معين ضمن عدد من الأطوارداخل الوسط المسامي. كما يعتبر خواص الصخور والموائع من الخواص الاساسية في عملية الجريان المتعدد للموائع بحيث يؤثر على توزيع الموائع داخل المكمن وكذلك على عملية استخلاص النفط .

يتم حساب النفاذية النسبية عن طريق التجارب المعملية التي تعتبر مكلفة وتستغرق وقتاً طويلاً ،حيث يتم اجراء التجارب على عدد محدود من العينات الصخرية مما يعطي نتائج لا توصف كل المكمن النفطي .هنالك شكوك في نتائج النفاذية النسبية عند استخدام طريقتين مختلفتين لنفس الطبقة .

الهدف الاساسي من هذه الدراسة هي قياس وحساب متوسط النفاذية النسبية للزيت والماء لعينات من الصخر الرملي باستخدام طريقة حالة عدم الاستقرار والطرد المركزي .وتشمل أيضاً التحقق والمقارنة لمنحنى النفاذية النسبية عند استخدام كل من الطريقتين .

وأظهرت المقارنة النهائية لمنحنيات النفاذية النسبية بين أجهزة الطرد المركزي وجهاز حالة عدم الاستقرارأن منحنيات النفاذية النسبية متماثلتان بالنسبة للمنحنيات الطورالغير متشبع، ولكن المنحنيات مختلفة الشكل تماما للطور المتشبع .

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