

A SIMULATION OF THE UNDERGROUND STORAGE OF NATURAL GAS

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A Thesis Submitted in Partial Fulfilment of the Requirements
for the Degree of Master of Science
The Petroleum and Petrochemical College, Chulalongkorn University
in Academic Partnership with
Case Western Reserve University, The University of Michigan,
The University of Oklahoma, and Institut Français du Pétrole

2004

ISBN 974-9651-26-X

L 21616395

Thesis Title: A Simulation of the Underground Storage of Natural Gas
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ABSTRACT

4471024063: PETROCHEMICAL TECHNOLOGY PROGRAM

Khomsak Chamnakyut: A Simulation of Underground Storage of Natural Gas

Thesis Advisors: Asst.Prof. Kitipat Siemanond, Assoc.Prof. Chintana Saiwanand, Prof. James O. Wilkes, 77 pp. ISBN 974-9651-26-X

Keywords: Natural Gas Storage/ Simulation

A numerical simulation program for predicting the pressure profile of natural gas in an underground storage reservoir was developed. The computer program was initially written using a two-dimensional model and a single layer to solve a governing equation that is a partial differential equation to obtain an approximate solution of the pressure distribution. A pressure profile was predicted and the amount of gas withdrawn from a reservoir was calculated using the numerical method called the implicit alternating-direction method (IAD), which was written in a FORTRAN program, including important parameters such as permeability, porosity, initial pressure, etc. In addition, the program was written to predict regular and irregular shapes of gas reservoirs at constant and inconstant permeability, the pressure distribution and production rate at different time steps. The simulated program is suitable for real applications, if it is further developed to a three-dimensional and multilayer model, because an accurate pressure profile and production rate can be obtained.

บทคัดย่อ

คมศักดิ์ จำแนกยุทธ์ : แบบจำลองการเก็บก๊าซธรรมชาติใต้ดิน (A Simulation of Underground Storage of Natural Gas) อ. ที่ปรึกษา ผศ.ดร. กิติพัฒน์ สีมานนท์ รศ.ดร. จินตนา สายวรรณ และ ศ.ดร. เจมส์ โอ วิลค์ 60pp หน้า ISBN 974-9651-26-X

การพัฒนาโปรแกรมจำลองแบบนิวเมอริคอล เพื่อทำนายความดันที่จุดต่างๆในแหล่งกักเก็บก๊าซธรรมชาติ ถูกพัฒนาขึ้นโดยโมเดลแบบสองมิติและระดับชั้นเดียวเพื่อแก้สมการพาเซิลดิฟเฟอเรนเชียลหาค่าการกระจายความดันโดยประมาณ การทำนายความดันก๊าซที่จุดต่างๆและทำนายปริมาณก๊าซที่ถูกดึงขึ้นมาจากแหล่งกักเก็บ โดยคำนวณจากวิธีนิวเมอริคอลที่เรียกว่าอิมพลิชิตอัลเทอร์เนติงไดเรกชัน(ไอเอดี) ซึ่งเป็นโปรแกรมที่เขียนด้วยภาษาฟอแทรนที่รวมตัวแปรสำคัญ เช่น ค่าความสามารถซึมผ่าน ค่าความพรุน ค่าความดัน เป็นต้น นอกจากนี้โปรแกรมยังถูกเขียนขึ้นมา เพื่อทำนายแหล่งกักเก็บก๊าซธรรมชาติที่มีรูปแบบธรรมดาและแบบไม่ธรรมดาที่ความสามารถซึมผ่านมีค่าคงที่และไม่คงที่ ทำนายการกระจายความดันก๊าซและอัตราการผลิตในช่วงเวลาต่างกัน โปรแกรมจำลองนี้เหมาะกับการประยุกต์ใช้งานได้จริงเมื่อพัฒนาให้อยู่ในรูปแบบโมเดลสามมิติ และมัลติเลเยอร์เพราะสามารถใช้ทำนายความดันก๊าซที่จุดต่างๆและอัตราการผลิตได้ถูกต้องแม่นยำ

ACKNOWLEDGEMENTS

This thesis could not be completed without the participation and support from several individuals and organization. I would like to thank all of them for making this thesis a success.

Firstly, out of the sense of gratefulness, I would like to express my deepest gratitude to Prof. James O. Wilkes, Asst. Prof. Kitipat Siemanond, and Assoc. Prof. Chintana Saiwan who took much care in guiding and assisting me devotedly and enthusiastically through my thesis work.

I especially extend my whole-hearted gratitude to thank my thesis committee, Assoc. Prof. Thirasak Rirksombomboon, and Asst. Prof. Pramoch Rangsunvigit for their well-intentioned suggestions and comments.

I would be remised if I did not express my acknowledgement to all of my friends in the college who play invaluable roles in my learning experience and all the Petroleum and Petrochemical College staff for their unforgettable assistance. And also, this thesis work is partially funded by Postgraduate Education and Research Programs in Petroleum and Petrochemical Technology (PPT Consortium).

Finally, I would like to extend my whole hearted gratitude to my family for their encouragement, and measureless support.

TABLE OF CONTENTS

	PAGE
Title Page	i
Abstract (in English)	iii
Abstract (in Thai)	iv
Acknowledgements	v
Table of Contents	vi
List of Figures	viii
List of Tables	x
List of Symbols	xi
CHAPTER	
I INTRODUCTION	1
II BACKGROUND AND LITERATURE SURVEY	3
2.1 Background	3
2.2 Literature survey	4
III PROBLEM SOLVING METHOD	7
3.1 Partial Difference Equation (PDE) Theory	7
3.2 The Finite Difference Approximation	7
3.3 The Implicit Form of the Differential Equation	10
3.4 The Implicit Alternating-Direction Method	11
3.5 Solution of Equation Resulting Form the Implicit Method	12
IV GAS STORAGE PROGRAM	13
4.1 Perturbation Analysis	13
4.2 Main Program	15
4.3 Compare with difference grid point.	31
4.4 Multiple wells	33
4.5 Physical property	37

CHAPTER	PAGE
4.6 Injection and withdrawal schedule.	39
4.7 Application	41
V CONCLUSIONS AND RECOMMENDATIONS	
5.1 Conclusions	44
5.2 Recommendations	44
REFERENCES	48
APPENDICES	50
Appendix A Source Code for Natural Gas Storage Problem .	50
Appendix B The relation between Φ and P.	58
Appendix C The relation between P and Φ .	59
CURRICULUM VITAE	60

LIST OF FIGURES

FIGURE	PAGE
3.1 The coordinate in x and y direction.	8
3.2 The implicit form.	10
4.1 Pressure profile at T = 0 sec.	13
4.2 Pressure profile at T = 20 sec.	14
4.3 Cross sectional view of Pressure profile at T = 20 sec.	14
4.4 Pressure profile at T = 0 sec.	15
4.5 Pressure profile at T = 10 sec.	16
4.6 Cross sectional view of pressure profile at T = 10 sec.	16
4.7 Permeability profile (input data).	17
4.8 Cross sectional view of permeability profile.	17
4.9 Pressure profile at T = 10 days.	18
4.10 Cross sectional view of Pressure Profile at T = 10 days.	18
4.11 Pressure profile at T = 100 days.	19
4.12 Cross sectional view of Pressure Profile at T = 100 days.	19
4.13 Pressure profile at T = 10 days.	20
4.14 Cross sectional view of Pressure Profile at T = 10 days.	20
4.15 Pressure profile at T = 100 days.	21
4.16 Cross sectional view of Pressure Profile at T = 100 days.	21
4.17 Pressure profile at T = 10 days.	22
4.18 Cross sectional view of pressure Profile at T = 10 days.	22
4.19 Pressure profile at T = 100 days.	23
4.20 Cross section area of pressure Profile at T = 100 days.	23
4.21 Permeability profile.	24
4.22 Cross sectional view of permeability profile.	24
4.23 Pressure Profile at T = 10 days.	25
4.24 Cross sectional view of pressure profile at T = 10 days.	25
4.25 Pressure profile at T = 100 days.	26
4.26 Cross sectional view of pressure Profile at T = 10 days.	26

FIGURE	PAGE
4.27 Permeability profile.	27
4.28 Cross sectional view of permeability profile.	27
4.29 Pressure profile.	28
4.30 Cross sectional view of pressure profile.	28
4.31 Pressure profile.	29
4.32 Cross sectional view of pressure Profile.	29
4.33 Pressure Profile.	30
4.34 Cross sectional view of pressure Profile.	30
4.35 Initial pressure profile.	31
4.36 The pressure profile after 100 days.	31
4.37 Initial pressure profile.	32
4.38 The pressure profile after 100 days.	32
4.39 Initial pressure profile.	33
4.40 The pressure profile after 40 days.	33
4.41 Initial pressure profile.	34
4.42 The pressure profile after 40 days.	34
4.43 The pressure Profile of an 11, 11 grid reservoir.	35
4.44 The pressure Profile of a 21, 21 grid reservoir.	36
4.45 The pressure profile of reservoir.	36
4.46 The result of pressure from the natural gas storage program.	39
4.47 Injection and withdrawal schedule	40
4.48 Carbonate Reservoir.	41
4.49 Permeability profile.	41
4.50 Cross sectional view of permeability profile.	42
4.51 Pressure profile.	42
4.52 Cross sectional view of pressure Profile.	43
5.1 The layer of the reservoir.	45
5.2 The input data of reservoir simulation.	46
5.3 The results of reservoir simulation.	47

LIST OF TABLES

TABLE		PAGE
4.1	The grid point in comparison.	38
4.2	The result of pressure from the natural gas storage program.	38
4.3	Injection and withdrawal data.	40

LIST OF SYMBOLS

c	Conversion factor, $6.327 \times 10^{-3} \text{ cp ft}^2/\text{psia day md}$.
c_x, c_y	Auxiliary quantities defined in text.
h	Vertical thickness of the gas storage field, ft.
k	Rock permeability, md.
L	Length of the reservoir in x direction.
m, n	Number of grid in x and y direction.
M	Mass withdraw rate of gas per unit volume, $\text{lb}_m/\text{ft}^3 \text{ day}$.
M_w	Molecular weight of gas, $\text{lb}_m/\text{lb mole}$.
p	Gas absolute pressure, psia.
p_d	Minimum acceptable delivery pressure, psia.
p_s, T_s	Standard pressure and temperature.
p_w	Wellbore pressure, psia.
Q_s	Total withdraw rate of gas, SCF (standard cubic feet)/day
q_s	Total withdraw rate of gas, SCF (standard cubic feet) of of gas per cubic foot of reservoir per unit time, days^{-1} .
Q_{\max}	Maximum value of Q_s
R	gas constant
r_e	Effective drainage radius of well, ft.
r_w	Wellbore radius, ft.
R	Gas Constant.
t	Time, days.
t_{\max}	Total simulation time, days.
T	Gas Temperature, $^{\circ}\text{R}$.
v_x, v_y	Superficial velocities in the x and y directions, ft/day.
W	Width of the reservoir (in the y direction), ft.
x, y	Coordinates in the horizontal plane, ft.
z	Compressibility factor.
α, β, δ	Auxiliary quantities defined in text.
$\Delta x, \Delta y$	Grid spacing in the x and y directions, ft, such that $\Delta x = L/m$ and $\Delta y = W/n$

Δt	Time step, days.
μ	Gas viscosity, cp.
ρ	Gas density, lb _m /ft ³ .
ε	Porosity of the rock formation.
Φ	Gas potential, (psia) ² /cp.