

# **ADI METHOD FOR 3-D RESERVOIR SIMULATION**

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**ABSTRACT**

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This reservoir simulation is done by a numerical method which is used to predict the amount of natural gas in a reservoir and reservoir lifetime. This thesis work was focused on developing three-dimensional simulation model for a natural gas reservoir. The governing equations of the reservoir model are transient mass transport and Darcy's law. The numerical method, finite difference (FDM) was applied to solve these equations by the alternating-direction implicit (ADI) technique combined with FORTRAN programming. The reservoir model was initially assumed in rectangular, cylindrical and irregular shapes. The model can predict pressure profile and the production rate of the natural gas reservoir. The simulation result was compared to one of commercial software of finite element, FEMLAB, giving the 4.58 and 8.07 % error.

## บทคัดย่อ

หฤท จันทรเทพเทวัญ : การสร้างแบบจำลองสามมิติของแหล่งกักเก็บก๊าซธรรมชาติ โดยวิธีเอดีไอ (Alternating-Direction Implicit) (ADI method for 3-D Reservoir Simulation) อ. ที่ปรึกษา : ผศ. ดร. กิติพัฒน์ สีมานนท์ และ รศ. ดร. จินตนา สายวรรณ 121 หน้า

แบบจำลองแหล่งกักเก็บก๊าซธรรมชาติใช้สำหรับทำนายปริมาณก๊าซธรรมชาติ, อายุของแหล่งกักเก็บ, และ ตำแหน่งของหลุมขุดเจาะ งานวิจัยนี้ทำการศึกษาและพัฒนาแบบจำลองสามมิติของแหล่งกักเก็บก๊าซธรรมชาติ สำหรับสมการหลักที่ใช้ในงานวิจัยนี้ประกอบด้วย สมการสมมูลมวล และ สมการของคาร์ซี โดยใช้วิธีไฟไนต์ดิฟเฟอเรนเชียล ด้วยเทคนิคเอดีไอ ร่วมกับโปรแกรมฟอร์แทรน ซึ่งใช้ทำนายแหล่งกักเก็บรูปทรงสี่เหลี่ยม, รูปทรงกรวย, และ รูปทรงอิสระ แบบจำลองที่ได้สามารถทำนายสถานะต่างๆของแหล่งกักเก็บก๊าซธรรมชาติ ได้แก่ การกระจายของค่าความดัน และ อัตราการผลิตของก๊าซธรรมชาติ เมื่อนำผลที่ได้จากการทดลองนี้ไปเปรียบเทียบกับผลที่ได้จากโปรแกรมสำเร็จรูป หรือเฟมแล็บ พบว่าผลที่ได้จากเฟมแล็บมีค่าความถูกต้องมากกว่าผลที่ได้จากการทดลอง

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## LIST OF SYMBOLS

D	Well diameter, ft.
$f_F$	Fanning fraction factor.
g	Gravitational acceleration, 32.2 ft/s <sup>2</sup> .
k	Rock permeability, md.
L	Reservoir length, ft.
M	Mass withdraw rate of gas per unit volume, lb <sub>m</sub> /ft <sup>3</sup> day.
MW	Molecular weight of gas, lb <sub>m</sub> /lb mole.
$p$	Gas absolute pressure, psi.
$p_r$	Reservoir pressure, psi.
$p_s$	Standard pressure, psi.
$p_t$	Well bore pressure, psi.
$p_w$	Bottom well pressure, psi.
$Q_i$	Volume flow rate, MMSCFD.
$Q_w$	Gas withdrawal rate, MMSCFD.
$q_s$	The volumetric flow rate per volume at standard condition, days <sup>-1</sup> .
$r_e$	Equivalent radius of external boundary, ft.
$r_w$	Well radius, ft.
R	Gas constant.
t	Time, days.
$T_s$	Standard temperature, °R.
$T_r$	Reservoir temperature, °R.
W	Reservoir width, ft.
Z	Compressibility factor.
$\epsilon$	Porosity of the rock formation.
$\Phi$	Gas potential, (psi) <sup>2</sup> /cp.
$\mu$	Gas viscosity, cp.