

NAURAL GAS RESERVOIR SIMULATION

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ABSTRACT

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Reservoir simulation is used to predict the amount of natural gas in a reservoir, the reservoir lifetime, the effects of reservoir uncertainties and continuity of pore space and fluids on production rate, and the well location. This thesis work was focused on the development of a validated two dimensions simulation model for a natural gas reservoir. The governing equations of the reservoir model are transient mass transport and Darcy's law. Two numerical methods, finite difference (FDM) and finite element (FEM), were applied to solve these equations. The reservoir model was initially assumed in regular, irregular and actual reservoir shapes. The model can investigate reservoir behavior such as pressure distribution, top-hole pressure, bottom well pressure and individual flow rate after natural gas withdrawal or injection with respect to time. At the same amount of grid blocks and elements from two numerical methods, FEM spent a little bit higher computation time than FDM. FEM predicted the reservoir pressure close to historical data, while the result from FDM was farther from historical data. The emphasis of the finite element method was placed on investigating the pressure profile in reservoir.

บทคัดย่อ

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แบบจำลองแหล่งกักเก็บก๊าซธรรมชาติใช้สำหรับทำนายปริมาณก๊าซธรรมชาติ อายุของแหล่งกักเก็บ, ผลกระทบของความไม่แน่นอนของแหล่งกักเก็บและความต่อเนื่องของช่องว่างและของไหลที่มีต่ออัตราการผลิตก๊าซธรรมชาติและตำแหน่งของหลุมขุดเจาะ งานวิจัยนี้ทำการศึกษาและพัฒนาแบบจำลองสองมิติของแหล่งกักเก็บก๊าซธรรมชาติ โดยใช้วิธีไฟไนต์ดิฟเฟอเรนเชียลและวิธีไฟไนต์เอลิเมนต์ สำหรับสมการหลักที่ใช้ในงานวิจัยนี้ประกอบด้วย สมการสมดุลมวลและสมการของคาร์ซี ใช้ทำนายแหล่งกักเก็บรูปทรงสี่เหลี่ยม, รูปทรงอิสระ และ แหล่งกักเก็บจริง แบบจำลองที่ได้สามารถทำนายสถานะต่างๆของแหล่งกักเก็บก๊าซธรรมชาติ ได้แก่ การกระจายของค่าความดัน, ความดันที่ปากหลุม, ความดันที่ก้นหลุม และอัตราการผลิตของแต่ละหลุม ภายหลังการผลิตและการเติม ณ เวลาต่างๆ เวลาที่ใช้ในการคำนวณของวิธีไฟไนต์เอลิเมนต์จะมากกว่าวิธีไฟไนต์ดิฟเฟอเรนเชียลเล็กน้อย ณ จำนวนบล็อกและเอลิเมนต์ที่เท่ากัน ข้อมูลที่ได้จากแบบจำลองนี้นำไปเปรียบเทียบกับข้อมูลจากแหล่งกักเก็บจริง พบว่า วิธีไฟไนต์เอลิเมนต์สามารถคำนวณค่าความดันได้ใกล้เคียงกับความเป็นจริง

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LIST OF SYMBOLS

C	Conversion factor, $6.327 \cdot 10^{-3}$ cP.ft ² /psi.day.md.
D	Well diameter, ft.
f_F	Fanning fraction factor.
g	Gravitational acceleration, 32.2 ft/s ² .
h^*	Vertical thickness of the gas storage field, ft.
k	Rock permeability, md.
L	Reservoir length, ft.
m, n	Number of grid division in x,y direction.
M	Mass withdraw rate of gas per unit volume, lb _m /ft ³ day.
MW	Molecular weight of gas, lb _m /lb mole.
p	Gas absolute pressure, psi.
p_{re}	Reservoir pressure, psi.
p_s	Standard pressure, psi.
p_w	Bottom well pressure, psi.
p_t	Well bore pressure, psi.
Q_i	Volume flow rate, MMSCFD.
Q_{in}	Gas injection rate, MMSCFD.
Q_w	Gas withdrawal rate, MMSCFD.
q_s	The volumetric flow rate per volume at standard condition, days ⁻¹ .
r_e	Equivalent radius of external boundary, ft.
r_w	Well radius, ft.
R	Gas constant.
R_p	Pore radius in reservoir rock, micrometer.
t	Time, days.
T_s	Standard temperature, °R.
T_{re}	Reservoir temperature, °R.
v_x, v_y	Superficial velocities in the x and y directions, respectively, ft/day.
W	Reservoir width, ft.
wd	Well depth, ft.

Z	Compressibility factor.
ε	Porosity of the rock formation.
Φ	Gas potential, (psi) ² /cp.
μ	Gas viscosity, cp.