Cairo University

PRODUCTION DATA ANALYSIS TECHNIQUES FOR SHALE GAS RESERVOIRS: COMPARISON STUDY

By

Shams Noeman Mohamed Coutry

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Petroleum Engineering

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Title of Thesis:

Production Data Analysis Techniques for Shale Gas Reservoirs: Comparison Study

Key Words:

Production Data Analysis; Shale Gas Prediction; Shale Gas History Match, Shale Gas Reservoirs.

Summary:

The main objective of this work is to know the best method to use in shale gas production data analysis and in forecasting. The best method is known using a developed program. The developed program is verified using many comparison cases from Eclipse. The program was then used on actual field data.

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Dedication

My Parents & My Brother,
The purest hearts ever, I would have done nothing without your support, you taught me to trust in Allah and believe in hard work

My Love,
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Thank You All For Being in My Life

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Nomenclature

Abbreviations

EIA	Energy Informative Administrator
EUR	Estimate Ultimate Recovery
IEA	International Energy Agency
SEPD	Stretched Exponential Production Decline
SRV	Stimulated Reservoir Volume
USRV	Unstimulated Reservoir Volume
VBA	Visual Basic
YM-SEPD	Modified Stretched Exponential Production Decline

Symbols

Ac	Cross sectional area, ft^2
B	Oil formation volume factor, rbbl/stb
b	The degree of curvature of the line, dimensionless
cg	Gas compressibility, psi^{-1}
c_t	Total compressibility, psi^{-1}
D	Loss ratio, $days^{-1}$
D_i	Initial loss ratio, $days^{-1}$
D_∞	Loss ratio at t= ∞ , $days^{-1}$
G	Original gas in place, mmscf
h	Thickness, ft
I_0	Modified Bessel function of the first kind of order zero
I_1	Modified Bessel function of the first kind of order one
J_g	Productivity index of gas reservoir, Mscf.cp/day/Psi^2
k	Formation permeability, md
k_f	Hydraulic fracture permeability of dual porosity, md
k_0	Modified Bessel function of the second kind of order zero
k_1	Modified Bessel function of the second kind of order one
L	Distance to the boundary, ft
$m(p)$	Real gas pseudo-pressure, psi^2/cp
$m(p_{wf})$	Real gas pseudo-pressure at bottom-hole flowing pressure, psi^2/cp
$m(p_i)$	Real gas pseudo-pressure at initial pressure, psi^2/cp
m_{wDL}	Real gas dimensionless pseudo-pressure

N	Original oil in place, MMSTB
n	Time exponent
P	Pressure, psia
$\bar{p}$	Average reservoir pressure, psia
p_i	Initial reservoir pressure, psia
p_d	Dimensionless pressure
p_{sc}	Pressure at standard condition, psia
p_{wf}	Bottom-hole flowing pressure, psia
p_{wDL}	Dimensionless bottom-hole pressure
q_g	Gas production rate, mmscfd
q_{gi}	Initial gas production rate, mmscfd
r	Radius, ft
r_d	Dimensionless radius
r_e	Reservoir outer radius, ft
r_{ed}	Dimensionless reservoir radius
r_w	Wellbore radius, ft
s	Skin factor
SG	Specific gravity
t	Time, days
t_a	Material balance time, days
t_d	Dimensionless time
T	Temperature, ° R
T_{sc}	Temperature at standard condition, ° R
λ	Interporosity flow coefficient
ω	Storativity coefficient
∅	Porosity
Z	Real gas compressibility factor
Δp_{pwf}	Normalized bottom-hole pressure, psi^2/cp
µ	Viscosity, cp
γ_g	gas specific gravity

Abstract

There are several methods for production data analysis from shale gas reservoirs. In this study, nine different methods were used to analyze production data from 38 shale gas wells. The objective of this comparison study is to provide guidelines on which methods to use for production data analysis in shale gas wells. These nine methods include Arps' (1945), Fetkovich (1980), Fraim and Wattenberger (1987), Modified Hyperbolic (1988), El-Banbi and Wattenbarger (1998), Power Law Decline (2008), and Bello and Wattenbarger (2009). The variations of these methods to cover homogeneous, pseudo-steady state dual porosity, transient dual porosity, constant pressure and constant rate closed reservoirs are all considered in the comparison.

Production data from the 38 wells were categorized into three groups to cover the different conditions of observed rate and pressure variation. For every group of wells, half of the production history was history matched with all nine methods, and the other half of production history was predicted. The deviation between predicted production forecast and actual production was used to shed light on the applicability of each method of the nine for the three groups of wells.

The results indicate that the best constant pressure methods for most of the wells are Modified Hyperbolic and Power Law Decline with mean absolute deviation percent of 6% and 7.5%, respectively. In case of constant rate methods, the best method is found to be Bello and Wattenbarger with an average absolute error percent of 10%.

This study is an original contribution to provide guidelines to select the suitable production data analysis technique in the shale gas reservoir.