Evaluation of Multi-Phase Mechanistic Models for Vertical and Deviated wells

By

Mohamed El-Hussien El-Dessouky El-Dessouky

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

FACULTY OF ENGINEERING, CAIRO UNIVERSITY

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Under the Supervision of

Prof. Ahmed Hamdy El-Banbi	**Prof. El-Sayed Ahmed Al-Tayeb**
………………………………	………………………………
Professor of Petroleum Engineering Mining, Petroleum & Metallurgical Engineering Department, Cairo University	Head of Mining, Petroleum & Metallurgical Engineering Department, Faculty of Engineering, Cairo University

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Approved by the
Examining Committee

____
Prof. Ahmed Hamdy El-Banbi, Thesis Main Advisor
Professor of Petroleum Engineering, Cairo University

____
Prof. El-Sayed Ahmed Al-Tayeb, Advisor
Head of Mining, Petroleum & Metallurgical Engineering Department, Cairo University

____
Prof. Khaled Abd El-Fattah, Internal Examiner
Professor of Petroleum Engineering, Cairo University

____
Eng. Nabil Salah, External Examiner, External Examiner
Vice Chairman of the Egyptian General Petroleum Corporation

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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2018

Engineer's Name: Mohamed El-Hussien El-Dessouky
Date of Birth: 8/1/1989
Nationality: Egyptian
E-mail: Eldessoukyme@gupco.net
M.elhussien89@gmail.com
Phone: 01003506045
Address: No. 96, 23 July street, Port-Said, Egypt

Registration Date: 1/3/2012
Awarding Date: 2018
Degree: Master of Science
Department: Mining, Petroleum and Metallurgical Engineering

Supervisors: Prof. Dr. Ahmed Hamdy El-Banbi

Prof. Dr. El-Sayed Ahmed Al-Tayeb

Examiners: Eng. Nabil Salah (External examiner)
- Vice President, Egyptian General Petroleum Corporation

Prof. Dr. Khaled Abdel Fattah (Internal examiner)
Prof. Dr. Ahmed Hamdy El-Banbi (Thesis Main Advisor)
Prof. Dr. El-Sayed Ahmed Al-Tayeb (Advisor)

Title of Thesis:

EVALUATION OF MULTI-PHASE MECHANISTIC MODELS FOR VERTICAL AND DEVIATED WELLS

Key Words:

Mechanistic Models - Multi-phase flow - Pressure drop calculations

Summary:

Development of Models to accurately calculate pressure drop along wells and pipelines has always been a challenge to scientists and engineers. This thesis presents an evaluation of the most commonly used Mechanistic Models. Selected Mechanistic Models were first programmed using C# programming language, then, a comprehensive evaluation of these models was done using a large set of test points (1,418 points). The results of the programmed models were further analyzed; where three new methods were developed based on this analysis. All the programmed models/methods were tested against new field data (132 points) and compared with commonly used models in oil field.

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Dedication

I would like to dedicate this thesis to my wife, my mother and all my family members for their outstanding support. They deserve a lot and there is nothing can express my love and pride toward them.

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Nomenclature

A	Area
API	Liquid Gravity in °API
CP	centipoise
d	Inside pipe diameter
$\frac{dp}{dl}$	Pressure gradient
E_K	Dimensionless kinetic energy pressure gradient
Eo	Evotos number
f	Friction factor
F	Fahrenheit
FE	Liquid entrainment in the gas core
ft	Feet
g	Gravity acceleration
g_c	Conversion constant
k	Relative roughness
l	Length
N_d	Dimensionless pipe diameter number
N_{Fr}	Froude number
N_{lv}	Dimensionless liquid velocity number
N_{gv}	Dimensionless gas velocity number
N_{Re}	Reynolds number
N_{we}	Weber number
N_{μ}	Viscosity number
P	Pressure
P_b	Bubble point pressure
P_{wf}	Bottom hole flowing pressure
ppm	Part per million
q	Flow rate
R	Rankine
R_{sb}	Solution gas-oil ratio
T	Temperature
v	Velocity
Z	Gas compressibility factor

Greek letters

$\boldsymbol{\alpha}$	Gas void fraction
$\boldsymbol{\beta}$	Formation volume factor
$\boldsymbol{\delta}$	Dimensionless film thickness
$\boldsymbol{\varepsilon}$	Absolute roughness
$\boldsymbol{\gamma}$	Specific gravity
$\boldsymbol{\lambda}$	No-slip holdup
$\boldsymbol{\mu}$	Viscosity
$\boldsymbol{\Psi}$	Inclination correction factor
$\boldsymbol{\rho}$	Density
$\boldsymbol{\sigma}$	Interfacial tension
$\boldsymbol{\tau}$	Shear stress
$\boldsymbol{\theta}$	Inclination angle from horizontal

Subscripts

av	Average
b	Bubble
c	Gas core
crit	Critical
el	Elevational
f	Frictional
g	Gas
I	Interfacial
l	Liquid
lf	Liquid film
ls	Liquid slug
n	Normalizing
ns	No-slip
m	Mixture
min	Minimum
o	Oil
p	Pipe
s	Slip
sg	Superficial gas
sl	Superficial liquid