



Cairo University

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

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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.

Table of Contents

Acknowledgement	i
Dedication	ii
Table of Contents	iii
List of Tables	vii
List of Figures	viii
Nomenclature	x
Abstract	xiii
Chapter 1: Introduction	1
Chapter 2: Literature Review	3
2.1 Single Phase Flow	3
2.1.1 The General Energy Equation	3
2.1.2 Friction Factor	4
2.2 Two Phase Flow	5
2.2.1 Gas Slippage	5
2.2.2 Superficial Velocity	6
2.2.3 Flow Patterns	7
2.2.4 Flow Pattern Map	8
2.2.5 Liquid Holdup.....	8
2.2.6 Two Phase Mixture Properties	9
2.2.7 The General Energy Equation for Two Phase Flow	10
2.3 Empirical Correlation.....	11
2.3.1 Poettmann-Carpenter Correlation (1952)	11
2.3.2 Fancher-Brown Correlation (1963)	12
2.3.3 Hagedorn-Brown Correlation (1964)	12
2.3.4 Duns-Ros Correlation (1963).....	13
2.3.5 Orkiszewski Correlation (1967).....	14
2.3.6 Beggs and Brill Correlation (1973)	14
2.3.7 Chierici et al. Correlation (1974).....	15
2.3.8 Cornish Correlation (1976)	15
2.3.9 Mukherjee-Brill Correlation (1985).....	15
2.4 Mechanistic Models	16
2.4.1 Aziz-Govier-Fogarasi Model (1972)	16
2.4.2 Ozon et al. Model (1987).....	17

2.4.3 Hasan-Kabir Model (1988).....	17
2.4.4 Xiao-Shoham-Brill Model (1990).....	17
2.4.5 Ansari et al. Model (1994).....	18
2.4.6 Chokshi-Schmidt-Doty Model (1996)	19
2.4.7 Petalas-Aziz Model (1996)	20
2.4.8 Gomez et al. Model (1999).....	20
2.4.9 Kaya-Sarica-Brill Model (1999).....	21
2.4.10 Mars et al. Model (2007)	21
2.5 Neural Network Models	21
2.6 Software packages used for calculating pressure drop.....	22
2.6.1 Prosper Software.....	22
2.6.2 Pipesim Software	23
Chapter 3: Statement of The Problem and Objectives.....	25
Chapter 4: Model Construction and Evaluation.....	26
4.1 PVT Correlations Selection.....	26
4.2 Mechanistic Models Selection and Programming.....	26
4.3 Database Gathering and Filtration.....	28
4.4 Models Validation	29
4.5 Mechanistic Models Evaluation	39
Chapter 5: Development of New Methods.....	44
5.1 Data Grouping Method.....	44
5.2 Switching Method	47
5.2.1 Combining a Single Pattern Map with a Single Calculation Model for All Patterns	47
5.2.2 Combining a Single Pattern Map with a Separate Calculation Model for Each Pattern.....	49
5.2.3 Evaluation of Switching Method	52
5.3 Nearest Point Method.....	53
5.3.1 Method Calculation Steps.....	54
5.3.2 Evaluation of Nearest Point Method	56
Chapter 6: Field Application	58
6.1 Data Gathering and Models Selection.....	58
6.2 Evaluation of Programmed Models.....	58
Chapter 7: Conclusions and Recommendations	66
7.1 Conclusions	66

7.2 Recommendations	67
References	68
APPENDIX (A)	72
A.1 Aziz Govier Fogarasi Model	73
A.1.1 Flow Pattern Map	73
A.1.2 Bubble Flow Model	74
A.1.3 Slug Flow Model	74
A.1.4 Churn Flow Model.....	75
A.1.5 Mist Flow Model	75
A.2 Hasan Kabir Model	77
A.2.1 Flow Pattern Map	77
A.2.2 Bubble/Dispersed Bubble Flow Models	77
A.2.3 Slug Flow Model	78
A.2.4 Churn Flow Model.....	78
A.2.5 Mist Flow Model	79
A.3 Ansari et al. Model	80
A.3.1 Flow Pattern Map	80
A.3.2 Dispersed Bubble Flow Model	82
A.3.3 Bubble Flow Model	83
A.3.4 Slug Flow Model	83
A.3.5 Mist Flow Model	85
A.4 Kaya Sarica Brill Model.....	87
A.4.1 Flow Pattern Map	87
A.4.2 Dispersed Bubble Flow Model	89
A.4.3 Bubble Flow Model	89
A.4.4 Slug Flow Model	89
A.4.5 Churn Flow Model.....	91
A.4.6 Mist Flow Model	92
A.5 Chokshi Schmidt Doty Model.....	93
A.5.1 Flow Pattern Map	93
A.5.1 Bubble Flow Model	94
A.5.2 Slug Flow Model	94
A.5.3 Mist Flow Model	95
A.6 Gomez et al. Model	97
A.6.1 Flow Pattern Prediction Model.....	97

A.6.2 Dispersed Bubble/Bubble Flow Models	97
A.6.3 Slug Flow Model	98
A.6.4 Mist Flow Model	99
A.7 Beggs Brill Model	102
A.7.1 Basic Equation	102
A.7.2 Flow Patterns	102
A.7.3 Liquid Holdup.....	103
A.7.4 Friction Factor	104
A.8 Duns Ros Flow Pattern Map	105
APPENDIX (B)	107

List of Tables

Table 4.1: Summary of Selected PVT Correlations.....	26
Table 4.2: Range of Input Data After Filtration.....	28
Table 4.3: Input Data for The Well Used for Qualitative Validation	29
Table 4.4: Summary of Input Data Used for Quantitative Validation	31
Table 4.5: Results of Calculated Pwf for Well #1	32
Table 4.6: Results of Calculated Pwf for Well #2	33
Table 4.7: Results of Calculated Pwf for Well #3	35
Table 4.8: Results of Calculated Pwf for Well #4	36
Table 4.9: Results of Calculated Pwf for Well #5	38
Table 4.10: Unfiltered Data Results for All Models.....	40
Table 4.11: Filtered Data Results for All Models.....	41
Table 5.1: Criteria of Groups Classification.....	44
Table 5.2: Distribution of Groups According to Well Parameters	45
Table 5.3: Results of Combining a Single Pattern Map with a Single Calculation Model.....	47
Table 5.4: Bubble Flow Pattern Analysis	49
Table 5.5: Slug Flow Pattern Analysis	51
Table 5.6: Switching Method Results Compared to Other Models	53
Table 5.7: Nearest Point Method Results Compared to Other Models.....	56
Table 6.1: Range of Input Data Parameters.....	58
Table 6.2: Comparison Between Model Results for Each Well	60
Table 6.3: Comparison Between Results of 132 Test Points.....	65
Table A.1: Values of Factor m as a Function of Viscosity Number	75
Table A.2: Co Values as a Function of Inclination Angle	91
Table A.3: The Values of Coefficients a, b and c for Each Flow Pattern.....	103
Table A.4: The values of coefficients e, f, g and d for each flow pattern.....	104

List of Figures

Figure 2.1: Moody Diagram	4
Figure 2.2: Flow Patterns Existing in Vertical and Inclined Wells	7
Figure 2.3: Kaya-Sarica-Brill Flow Pattern Map.....	8
Figure 2.4: The energy Loss Friction Factor According to Poettmann-Carpenter	11
Figure 2.5: The energy Loss Friction Factor According to Fancher-Brown	12
Figure 2.6: Duns-Ros Flow Pattern Map	13
Figure 2.7: Orkiszewski Flow Pattern Map	14
Figure 2.8: Beggs-Brill Flow Pattern Map	15
Figure 2.9: Mukherjee-Brill Flow Pattern Map	16
Figure 2.10: Aziz-Govier-Fogarasi Flow Pattern Map	17
Figure 2.11: Hasan-Kabir Flow Pattern Map.....	18
Figure 2.12: Ansari et al. Flow Pattern Map.....	19
Figure 2.13: Chokshi et al. Flow Pattern Map	20
Figure 4.1: Flowchart Representing methodology steps	27
Figure 4.2: Pressure Gradient Curves of Beggs-Brill Model.....	30
Figure 4.3: Pressure Gradient Curves of Ansari et al. Model.....	30
Figure 4.4: Pressure Gradient Curves of Aziz-Govier-Fogarasi Model	31
Figure 4.5: Calculated Pressure Gradient Curves for Well #1	32
Figure 4.6: Comparison Between Calculated Error for Well #1	33
Figure 4.7: Calculated Pressure Gradient Curves for Well #2	34
Figure 4.8: Comparison Between Calculated Error for Well #2	34
Figure 4.9: Calculated Pressure Gradient Curves for Well #3	35
Figure 4.10: Comparison Between Calculated Error for Well #3	36
Figure 4.11: Calculated Pressure Gradient Curves for Well #4	37
Figure 4.12: Comparison Between Calculated Error for Well #4	37
Figure 4.13: Calculated Pressure Gradient Curves for Well #5	38
Figure 4.14: Comparison Between Calculated Error for Well #5	39
Figure 4.15: Filtered Data Results of Ansari Model.....	41
Figure 4.16: Unfiltered Data Results of Ansari Model.....	42
Figure 4.17: Filtered Data Results of Kaya Model.....	42
Figure 4.18: Unfiltered Data Results of Kaya Model.....	43
Figure 5.1: Switching Model Results Compared to Measured Data.....	53

Figure 5.2: Nearest Point Method Programming Flow Chart.....	54
Figure 5.3: An example for Calculation of 4,100 Feet Well Using NPM	55
Figure 5.4: Nearest Point Model Results Compared to Measured Data	57
Figure 6.1: Calculated Pressure Gradient Curves for Well #1 (Natural Flow).....	61
Figure 6.2: Calculated Pressure Gradient Curves for Well #2 (Natural Flow).....	61
Figure 6.3: Calculated Pressure Gradient Curves for Well #3 (Natural Flow).....	62
Figure 6.4: Calculated Pressure Gradient Curves for Well #4 (Gas Lift).....	62
Figure 6.5: Calculated Pressure Gradient Curves for Well #5 (Gas Lift).....	63
Figure 6.6: Calculated Pressure Gradient Curves for Well #6 (Gas Lift).....	63
Figure 6.7: Calculated Pressure Gradient Curves for Well #7 (Gas Lift).....	64
Figure 6.8: Calculated Pressure Gradient Curves for Well #8 (Gas Lift).....	64
Figure A.1: Flow Pattern Map of Aziz-Govier-Fogarasi Model.....	73
Figure A.2: Flow Pattern Map of Hasan-Kabir Model	77
Figure A.3: Flow Pattern Map of Ansari et al. Model.....	80
Figure A.4: Slug Flow Pattern Described by Ansari et al. Model	83
Figure A.5: Flow Pattern Map of Kaya et al. Model	87
Figure A.6: Slug Flow Pattern Described by Kaya et al. Model	90
Figure A.7: Mist Flow Pattern Described by Kaya et al. Model	92
Figure A.8: Flow Pattern Map of Chokshi et al. Model	93
Figure A.9: Slug Flow Pattern Described by Chokshi et al. Model	95
Figure A.10: Mist Flow Pattern Described by Chokshi et al. Model	96
Figure A.11: Slug Flow Pattern Described by Gomez et al. Model	98
Figure A.12: Mist Flow Pattern Described by Gomez et al. Model	100
Figure A.13: Flow Pattern Map of Beggs-Brill Model.....	102
Figure A.14: Flow Pattern Map of Duns-Ros Model	105
Figure A.15: Bubble-Slug Flow Pattern Transition Parameters	106

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
E_o	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

α	Gas void fraction
β	Formation volume factor
δ	Dimensionless film thickness
ε	Absolute roughness
γ	Specific gravity
λ	No-slip holdup
μ	Viscosity
Ψ	Inclination correction factor
ρ	Density
σ	Interfacial tension
τ	Shear stress
θ	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