



Cairo University

INCREASING MATURE OIL FIELDS PRODUCTION BY GAS LIFT OPTIMIZATION

By

Mohamed Mokhtar Mansour

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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Key Words:

Integrated Asset Modeling; Production Optimization; Intermittent Gas Lift Evaluation; Optimum Gas Lift Injection Depth; Flow Assurance.

Summary

Field wide optimization became mandatory in producing mature oil fields. Integrated asset model was created to optimize injection gas in mature oil field and saved 19 MMSCFPD with 330 bbls/day oil gain. Gas lift injection depth was deepened for some wells resulting in increasing oil production by 1700 bbls/day and saving 14 MMSCFPD. Intermittent gas lift was applied on low potential wells and saved 55% of injection gas requirements. The field was optimized for the best operating conditions to improve production.

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Dedication

In the name of Allah, I would like to dedicate this thesis to my parents who paid their time, money and support without any compensation to provide me with an outstanding education from the primary to post graduate studies. Their help and support encouraged me to improve myself and be a good engineer. This support always motivates me in all my works.

Table of Contents

Table of contents	vii
List of tables	x
List of figures	xii
Nomenclature.....	xv
Abstract.....	xvii
Chapter 1: Introduction.....	1
1.1 Background.....	1
1.2 Summary of Chapters	2
Chapter 2: literature review	3
2.1 Introduction and Fundamentals	3
2.2 Overview of Artificial Lift Methods	3
2.2.1 Types of Artificial Lift Methods.....	3
2.3 Gas Lift System	4
2.3.1 Principle of Gas Lift	4
2.3.2 Types of Gas Lift	5
2.3.2.1 Continuous Flow Gas Lift	7
2.3.2.2 Intermittent Gas Lift	8
2.3.2.3 Intermittent Gas Lift Review	8
2.4 Gas Lift Valves.....	8
2.4.1. Classification of gas lift valves.....	9
2.4.1.1. Injection pressure operated valves (IPO)	9
2.4.1.2. Production Pressure Operated Valves (PPO)	9
2.4.1.3. Pilot Valves	10
2.5 Gas Lift Optimization.....	11
2.5.1 Introduction	11
2.5.2 Individual Well Optimization.....	11
2.5.3 Gas Lift Allocation to a Group of Wells	14
2.5.3.1 Conventional Calculation Model.....	14
2.5.3.2 Field-Wide Optimization.....	16
2.5.4 Gas Lift Optimization Techniques	17
2.5.5 Gas Lift Optimization Review	18
2.6 Flow Assurance	22
Chapter 3: Statement of Problem	25
Chapter 4: Integrated Field Modeling And Production Optimization.....	27
4.1 Building Prosper Model	27
4.1.1 Prosper Overview	27
4.1.2 Working Procedure to Build up Prosper Model	27
4.1.3 Prosper Model Validation	45
4.2 Building Of General Allocation Package (GAP) Model	46

4.2.1 Introduction	46
4.2.2 Working Procedure to Build up a GAP Model	47
4.2.3 GAP Model Validation.	56
Chapter 5: Intermittent Gas Lift Evaluation	58
5.1 Introduction	58
5.2 Analytical Approach to Calculate Optimum Cycle	58
5.3 Intermittent Gas Lift Design Example	65
5.4 Selecting the Optimum Cycle Time	67
5.5 Evaluate Applying IGL Using Existing Gas Lift System	68
Chapter 6: Mature Oil Field Case Study	71
6.1 Introduction	71
6.2 Reservoir Description	72
6.3 Surface Facility	74
6.4 Current Field Conditions	75
6.5 Data Sources for Production Optimization	76
6.6 Gas Lift Optimization for (M) Field	76
6.6.1 Building Prosper Models	76
6.6.2 Building GAP Model	78
6.7 Intermittent Gas Lift Evaluation	78
Chapter 7: Results and Discussions	81
7.1 Introduction	81
7.2 Determine the Optimum Gas Lift Injection Rate	81
7.3 Determine the Optimum Injection Depth	87
7.3.1 Evaluate Wells' Performance at Optimum Gas Lift Injection Depth ...	87
7.3.2 Gas Lift Optimization after Changing the Injection Depth	90
7.4 Effect of Changing Injection Gas Specific Gravity	91
7.5 Evaluate the Effect of Changing Separator Pressure	92
7.6 Intermittent Gas Lift Evaluation	93
7.7 Flow Assurance in (M) Field Pipeline Network	98
7.8 Evaluate the PVT and VLP Correlations	100
Chapter 8: Conclusions and Recommendations	102
References	103
Appendices	108

List of Tables

Table 4.1 : PVT Input Data for W Reservoir Fluids	28
Table 4.2 : Comparison between the actual well test data and GAP Model Calculated data	55
Table 5.1 : Input Data for Intermittent Gas Lift Design of well E-2	63
Table 5.2 : Well E-2 Intermittent Gas Lift Calculation Summary	64
Table 5.3 : Well A-3 Input Data for Maximum Injection Pressure Calculations...	66
Table 6.1 : Comparison of Well Test and PROSPER Calculated Data.....	75
Table 6.2 : Maximum Injection Pressure Summary	77
Table 6.3 : Intermittent Gas Lift Design Using the Existing Gas Lift System.....	77
Table 6.4 : Intermittent Gas Lift Design Using Maximum Surface Injection Pressure.....	78
Table 7.1 : (M) Field Performance before and after Gas Lift Optimization	80
Table 7.2 : Comparison between the Current Condition and Optimization using 35 MMSCFPD.....	82
Table 7.3 : Comparison between Current and Optimum Injection Depth	97
Table 7.4 : Effect of Changing Injection Depth on Total (M) Field Performance (54 MMSCFPD)	86
Table 7.5 : Gas Lift Optimization Results after Deepening the Point of Injection	88.
Table 7.6 : Effect of Changing Separator Pressure on (M) Field	90
Table 7.7 : IGL Design Results using Maximum Surface Injection Pressure	91
Table 7.8 : Comparison between the Wells Performance before and after IGL Application	92
Table 7.9 : IGL Design Results using Existing Gas Lift System	93
Table 7.10 : Comparison between Wells Performance before and After IGL Application using Existing Gas Lift System	93
Table 7.11 : 8" Oil Pipeline Data form E to A Platforms (All wells are open).....	96
Table 7.12 : 8" Oil pipeline Data form E to A Platforms when only E-1 is Open .	96
Table 7.13 : 8" Oil line De-Bottlenecking Data	96
Table 7.14 : 8" Oil line Bottlenecking Limit (All wells are open)	97
Table 7.15 : Bottlenecking limit when the only E-1 and E-3 online	97
Table 7.16 : 8" Oil line Current Condition	97
Table 7.17 : 8" Oil line Bottlenecking Limit.....	98
Table 7.18 : Matched PVT correlation (B_o , R_s) for (M) Field Reservoir Fluids...	98
Table 7.19 : Matched PVT Correlations (Viscosity) for (M) Field Reservoir Fluids	98
Table 7.20 : VLP Matching Results	99

List of Figures

Figure 2.1 : Examples of Artificial Lift Systems	4
Figure 2.2 : Typical Gas Lift System	5
Figure 2.3 : Continuous Flow Gas Lift	6
Figure 2.4 : Intermittent Gas Lift operation	7
Figure 2.5 : Valve Parts for Single Element Bellows Valve	9
Figure 2.6 : Injection and Production Pressure Operated Gas lift Valves.....	10
Figure 2.7 : Schematic of Pilot Valve	11
Figure 2.8 : Gas Lift Performance Curve	12
Figure 2.9 : Well Performance Curves for Various Tubing Sizes	12
Figure 2.10 : GUF Curves	13
Figure 2.11 : Cost/Revenue Curve	14
Figure 2.12 : Optimization for group of wells with unlimited gas availability.....	15
Figure 2.13 : Principle of optimum gas allocation using equal slope.....	16
Figure 2.14 : Optimization of gas allocation (limited gas availability)	16
Figure 4.1 : System Summary Menu	27
Figure 4.2 : PVT Input Menu	28
Figure 4.3 : Actual PVT data at Reservoir Temperature.....	29
Figure 4.4 : PVT Regression	29
Figure 4.5 : PVT Correlations Parameters	30
Figure 4.6 : Comparison between Actual and Calculated PVT Data	31
Figure 4.7 : Gas Lift Input Data	32
Figure 4.8 : Deviation Survey	33
Figure 4.9 : Downhole Equipment Drawing	34
Figure 4.10 : Geothermal Gradient.....	34
Figure 4.11 : Average Heat Capacities	35
Figure 4.12 : Inflow Performance Relationship (IPR)	36
Figure 4.13 : VLP/IPR Match.....	37
Figure 4.14 : Heat transfer co-efficient calculation.....	37
Figure 4.15 : VLP correlation Comparison Curves.....	39
Figure 4.16 : Well D1 Tubing Correlation Matching.....	40
Figure 4.17 : VLP Correlation after Matching with Well Test Data.....	41
Figure 4.18 : Adjusting IPR based on Well Test Data	42
Figure 4.19 : Well D-1 Gas Lift QuickLook	43
Figure 4.20 : Well D1 Current Operating Conditions	43
Figure 4.21 : Well D1 Gas Lift Performance Curve.....	44
Figure 4.22 : Prosper Calculations versus Actual Well Test Data for Well A2.....	45
Figure 4.23 : Defining System Options	46
Figure 4.24 : Field (M) Production System Drawing.....	47
Figure 4.25 : HPG system of (M) Field.....	48
Figure 4.26 : Well Summary Screen	49
Figure 4.27 : IPR Input Data	50
Figure 4.28 : Control Data.....	51
Figure 4.29 : VLP Input Data	51
Figure 4.30 : Well Constraints Screen.....	52
Figure 4.31 : Pipe line Input Data	52
Figure 4.32 : VLP Generate Data	53
Figure 5.1 : Average Gas Temperature Calculation by Enthalpy Balance	61

Figure 5.2 : Well E-2 Intermittent Gas Lift Performance Curves	65
Figure 6.1 : (M) Field Location	69
Figure 6.2 : (M) Field Total Production Rates and Cumulative Produced Oil	70
Figure 6.3 : (M) Field schematic stratigraphic column	71
Figure 6.4 : Y Formation Structural Map	71
Figure 6.5 : (M) Field Pipeline Network	73
Figure 6.6 : Comparison between Current Well Test and Prosper Results	76
Figure 7.1 : Comparison between (M) wells' performance before and after Gas lift Optimization Using 54 MMSCFPD	81
Figure 7.2 : Comparison between Injection Gas Required before and after Gas lift Optimization Using 54 MMSCFPD	81
Figure 7.3 : Well H-3 Gas Lift Performance Curve	83
Figure 7.4 : Well D-6 Gas Lift Performance Curve	95
Figure 7.5 : Comparison between (M) wells performance before and after Gas lift Optimization Using 35 MMSCFPD	84
Figure 7.6 : Comparison between Injection Gas on (M) field wells before and after Gas lift Optimization Using 35 MMSCFPD	84
Figure 7.7 : Injection Depth Change with Increasing HPG Injection Pressure.....	87
Figure 7.8 : (M) Field wells Performance Change with Changing Injection Depth.....	87
Figure 7.9 : Effect of Injection Gas Specific Gravity on Wells' Performance	89
Figure 7.10 : Average Gas Temperature comparison.....	94
Figure 7.11 : Injection Gas Calculations Comparison.....	94
Figure 7.12 : Sensitivity of Injection Gas with Temperature	95

Nomenclature

A	Cross section area of the pipe, m ²
AOF	Absolute open flow, MMSCFPD
A _p	Valve port Area, in ²
A _b	Bellows Area, in ²
BOPD	Oil Rate, bbls/day
BFPD	Liquid Rate, bbls/day
B _g	Gas formation volume factor, bbl/scf
B _w	Water formation volume factor, bbl/stb
D/S	Downstream Pressure, psi
FPHF	Flowing Bottom Hole Pressure, psi
GOR	Gas Oil Ratio, scf/stb
GLVC	Gas Lift Valve Change
H	Height of perforated interval, ft
PI / J	Productivity Index, bbls/day/psi
P _i	Initial reservoir pressure, psi
P _t	Tubing Pressure, psi
P _R	Reservoir pressure, psi
P _{wf}	Bottom hole flowing pressure, psi
P _c	Closing Pressure, psi
P _b	Valve bellows pressure, psi
SCF	Standard cubic feet
SSSV	Subsurface Safety Valve
U	Heat Transfer Co-efficient, BTU/hr/ft
U/S	Upstream Pressure, psi
W.C	Water Cut, Percentage
Z	Gas compressibility factor
ρ _g	Gas density, bound per gallon
ρ _m	Gas / liquid mixture density, lbs/ft ³ (or kg/m ³)
ρ _w	Water density, bound per gallon
ΔP	Draw down pressure, Psi
STBOPD	Stock tack barrel oil per day

Abbreviations

a	Laminar flow coefficient.
CO ₂	Carbon dioxide
GAP	General Allocation Program
H ₂ S	Hydrogen Sulphide
IPR	Inflow Performance Relationship
IPO	Injection Pressure Operated
PPO	Production Pressure Operated
IAM	Integrated asset model
I.D	Inside Diameter
MMSCF	Millions Standard cubic feet
PVT	Pressure, Volume, and temperature
VLP	Vertical lift performance
N ₂	Nitrogen

Abbreviations (cont.)

P/F	Platform
LPG	Low-pressure gas
IGL	Intermittent Gas Lift
PLT	Production logging tool
HPG	High Pressure Gas
TGLR	Total Gas Liquid Ratio

Abstract

Gas lift is an artificial lift method in which gas is injected with high pressure into the tubing string through gas lift valve to reduce the formation fluid density and assist its production to surface.

In mature oil fields, water cut continuously increases and accordingly produced gas volume decreases to a limit not sufficient to compensate daily gas losses. This limited lift gas volume has to be optimally distributed on the wells to ensure maximum production capacity. Performance of mature field wells changes with production due to change in water cut or reservoir pressure; which results in changing gas lift injection depth and affects total field performance.

Low rate producing wells need high amount of injection gas to be produced continuously; and with limited injection gas volume, they are usually shut in. Finding a cost effective solution to produce these low potential wells is essential.

The work aimed to: (1) identify a road map for gas lift optimization methodology (2) evaluate the effect of changing reservoir pressure and W.C on gas lift injection depth on total field performance (3) evaluate applying intermittent gas lift (IGL) on low rate wells (4) evaluate the pipeline network for any possible bottlenecking or flow assurance problems (5) determine the VLP and PVT correlations that best match mature field performance.

An integrated asset model was developed for the gas lift wells and surface network using PROSPER and GAP software. The developed model was matched with actual well test data and resulted a good match. Analytical approach was used to apply IGL on low potential wells, evaluate their performance, and the requirement to change the entire gas lift system. Simple average method was developed to calculate the average temperature below liquid slug. The results of this method were compared to the enthalpy balance method calculations and yielded a good match.

Applying gas lift optimization and IGL approaches on a mature field (M) resulted in saving 19 MMSCFPD and an oil gain of 330 bbls/day. On the other hand, some wells on (M) field are candidates for deepening the point of gas injection with an oil gain of 1700 BOPD and saving 14 MMSCFPD .

Applying intermittent gas lift on seven low rate wells in (M) field resulted in saving 8.0 MMSCFPD (55% of current injection gas rate). Calculating injection gas rate using simple average temperature showed a deviation of 2% from calculations using enthalpy balance method. In addition, the pipeline network was evaluated for any possible flow assurance problems in order to ensure safe operating conditions. Finally, the best PVT and VLP correlations that match (M) field performance are evaluated..

Chapter 1 : Introduction

1.1. Background

Gas lift is an artificial lift method in which gas is injected with high pressure into the tubing string through gas lift valve to reduce the formation fluid density and assist its production to surface. On the surface, low-pressure gas, formation gas, and injected gas lift are separated from liquid and used as a suction for gas compressors. Gas lift network is a closed system with daily gas losses due to fuel of gas compressors and surface facility in addition to flared gas.

During the life of gas lift well, water cut increases and produced gas volume decreases to a limit not sufficient to compensate daily gas losses in the network. In this situation, the limited injection gas volume has to be optimally distributed to ensure maximum production capacity.

In mature field, reservoir pressure, production rate, and water cut of wells changes and so the vertical lift performance, which results in changing gas lift injection depth. Unfortunately, some gas lift wells are equipped with orifice valves above the deepest gas lift mandrel, which limit further deepening to the point of injection and results in losing oil production.

Low potential wells, due to either low reservoir pressure or low productivity index, need high amount of injection gas to produce continuously. Usually these wells are circulating lift gas or producing with high injection gas rate compared with its oil production. With limited injection gas volume, these wells become not economical to produce and usually shut in. Finding a cost effective solution to produce these low rate wells is essential.

The surface facility of offshore oil field consists of many wellhead platforms connected to the main platform through oil and HPG pipelines. Oil is produced from wells on the wellhead platforms through oil pipeline to production separator on the main complex where LPG is separated and directed to a multi-stage gas compressor. Compressed gas is re-injected back to the wells through HPG network. Oil production through pipelines has to be optimized to prevent bottlenecking and flow assurance problems.

The gas lift well should be tested at different injection gas rates to create its gas lift performance curve, which can be used for gas lift optimization. In Mature fields, the surface network facility is usually not flexible for testing obligations, as only one testing line is available and test separator is usually out of service. So that optimizing well performance by testing it at different injection gas rates is very difficult.

In literature, different methods are used to optimize injection gas on a group of wells. One of the industry standard optimization software that is used to simulate well performance is PROSPER. Each well in the field is simulated separately using PROPSEER and matched with actual PVT samples and well test data. Then wells are integrated with the surface network and production facility using GAP software to build an integrated asset model.

In this thesis, integrated asset model is used to optimize injection gas on each well in the network. Then the wells are evaluated for possibility of deepening the gas lift