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Implementation Gas Lift Selection Technique and Design in the Wafa Field of Ghadamis Basin, West Libya

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Abstract**—**Implementing of a continues flow gas lift system for one vertical oil well producer in Wafa field was investigated under five reservoir pressures and their dependent parameters. Well 03 producers were responded positively to the gas lift system despite of the high well head operating pressures. However, the flowing bottom hole pressures were reduced by a ratio from 6 to 33 % in the case A3 for example, for the design runs conducted under the existing operating conditions for years 2003, 2006 and 2009. This reduction in FBHP has increased the production rate by a ratio from 12 to 22.5%. The results indicated that continues flow gas lift system is a good candidate as an artificial lift system to be considered for the one vertical producer covered by this study. Most significantly, timing for artificial lift by a gas lift system for this field is highly dependent on the amount of gas available at the time of implementation because of the high gas production rate from the top of the reservoir.

Keywords**—**Gas lift, Wafa field, Ghadamis Basin, Artificial lift, Libya.

I. Introduction

THE Wafa field is a gas-condensates reservoir with an oil rim located about 600km southwest of Tripoli in the NC169A Concession, (Fig. 1) along the Libyan-Algerian border, east of Algerian field of Alrar Wafa is a stratigraphic trap formed by F3 sandstone member of the Aouinet Ouenine Formation of Middle Devonian. Wafa is mainly a gas condensate reservoir with an average gross pay thickness of 100 ft underlain down dip by a small oil leg 40°API, 62 ft thick [1], [3].

Wafa field is subdivided into two areas, northern and southern. With regards to the depositional model, the general feeling is that all the gravity flows coming from the Tihemboka element deposited the bulk of their load in the Algerian sector and those them divided in at least two branches giving origin respectively to the Wafa North and Wafa South. While the southern part of Wafa was discovered in 1964 by the well D1 drilled by Shell the northern one, which is the largest, was discovered by Sirte Oil Company in 1991 with well A1. This sandstone wedge pinches out towards south and east; northwards the closure is by aquifer After A1 Sirte Oil Company started from 1991 to 1994 and extensive appraisal campaign with the drilling of additional 7 wells, A2 to A8.

The amount of the measured maximum liquid drop out (as per A8 well testing results), indicating a nature of lean gas condensate fluid. A negligible composition variation with depth has been observed for the deeper wells. The average gas gravity is about 0.80 (air=1) and the condensate specific gravity is about 65° API [9].

After the last reservoir study (Western Libya Gas Project) [6], where the development strategy was defined, four more appraisal wells (A9 to A12) were drilled by Agip Gas BV in the period 1998-1999 [8].

The development phase, started at the end of 2001, planned the work over of the existing8 wells (A1-A9) and the drilling of additional 29 wells (A13-A41) for a total of 37 wells. At the time being three development wells have been added on the Libyan Algerian border (A42-A44) to reduce the impact of the production regime in AlRar [4].

The formation of the reservoir was essentially a sandstone of the Middle Devonian age [10] situated in the F3 level Aouinet Ouenine "B" Formation, hydraulically connected with the Algerian Al Rar field. The formation was divided into four main levels characterized as follows:

1. The "upper" layer very good petrophysical parameters;
2. The "medium" layer good petrophysical parameters;
3. The "lower" layer not productive;
4. The "shaly" layer: completely tight.

The net pay considered in the interpretations was the sum of the middle and upper layer thicknesses limited by GOC upward and by the OWC downward [2], [4].

The present study, originally titled "WAFA FIELD –Oil Zone – Reservoir Model Revision and Well Productivity study ", was commissioned by Agip Gas in February 2003 and had initially to be focused on the oil zone due to the first unexpected results of the oil wells ENI Milan (TEOP and GIAC Dept) was involved with the main objectives of:

- Evaluating all the data recorded during the first phase of the development plan with particular attention to the north zone (A39, originally planned as a gas well, found a deeper and lower permeability reservoir interval).
- Analyzing the well testing results (well A06 not producing, A03 producing with high GOR and A18 with low FTHP).

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- Proposing remedial/alternative actions (acid remedial jobs, mixture acid selection, confirmation, / relocation of the 4 remaining oil wells in the northern zone).

To achieve the above main target the reservoir model was completely revised in both geological (reservoir top, layering and petro-properties description) and dynamical (model gridding, well productivity and VLP) properties to better represent the behaviors of the full Field (gas and oil zone).The work has been done in the period February-November 2003[7].

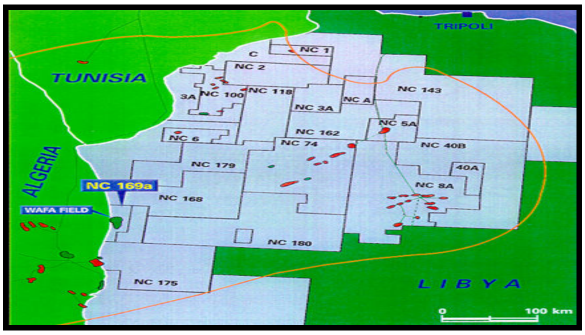

Fig. 1 Wafa Field Concession [5]

II. Method of Study

To predict timing for the artificial lift system, sensitivity runs were conducted using Wellflo software package developed by Edinburgh Petroleum Services 2006 EPS Ltd.

III. Well History

The A3 was a vertical well. The reservoir was drilled through with a 8½" bit, completed with a 7" casing and 4 1/2" string production The interval was perforated in overbalance condition from 8630 ft KB TVD to 8655ft KBTVD using a 4 1/2" HSD casing guns with 12 SPF. From side the production history (Fig. 2).

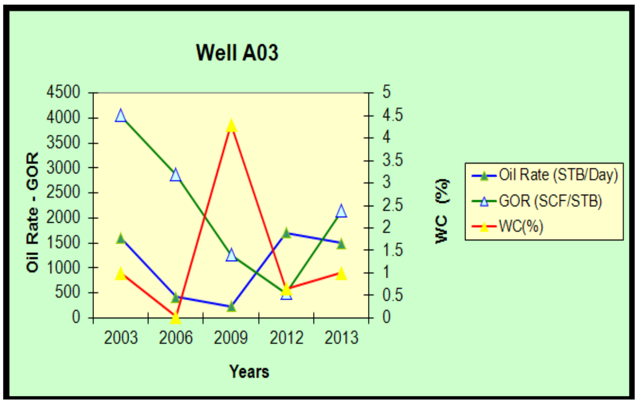

Fig. 2 Production history of well A03 for years 2003, 2006, 2009, 2012, and 2013

IV. Timing of Artificial Lift & Results

In a depletion drive reservoir, natural flow period is highly dependent on the reservoir pressure, size of the gas cap and the amount of dissolved gas. So, it is anticipated that flow rate will decline until the economic limit is reached.

TABLE I
Design Results of Well A03 for Years 2003,2006,2009,2012 and 2014

Years	Liquid Rate Before lifting (STB/day)	FBHP Before Lifting (Psia)	Liquid Rate After lifting (STB/day)	FBHP After Lifting (Psia)	FWHP (Psia)	Gas Injection Rate (MMSCFD)	W.C %
2003	1625	1185	1607	1208	741	6.456	1
2006	420	2117	514	1989	1000	1.476	0.03
2009	246	1442	302	1140	710.5	0.367	4.3
2012	1716	745	1165	1130	248	1.333	0.65
2014	989	996	1349	725	248	1.778	1.2

In the gas lift wells some of the variables, which affect production rate can be controlled and some cannot be controlled. The first category includes tubing size, flow line size, surface injection pressure, and separator pressure. The second categories include the reservoir static pressure, water cut, the fluid properties as API gravity and GOR. Given a set of the well condition, any change in one of the variable will change the production rate and injection rate.

In addition, commencing an artificial lift system at early stages of the reservoir life is more efficient to provide flexible drawdown through the rest of the production life. This will eliminate the restriction made by tubing string capacity for specific gas volumes to be injected if continues flow gas lift system is installed. So that production rate can be increased or maintained at an economic rate (Fig. 3, Tables I, II)

The back pressure resulting from the gathering and separation systems were considered as a basic design parameter to evaluate:

1. Individual well performance with gas lifts system under the actual flow line pressure.
2. Increasing drawdown by reducing FBHP to reduce reservoir pressure declining rate.

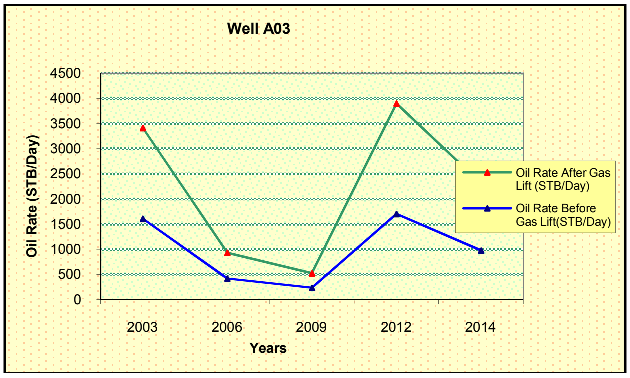

Fig. 3 Output design results of well A03

Introducing an artificial lift system at early stages of depletion may not be attractive from the economic point of view but, in case of Wafa field, it should be reviewed carefully because of the field location and history. This was examined by conducting design runs based on actual field data collected on January 2003 before the field was put into production.

One additional design run was performed for well A03 for year 2014 producer where the well head pressure was set at 248 psi to eliminate the back pressure effect. The design output results indicated that flow rate was increased by 36.4 % (Figs. 4-8 & Table III).

TABLE II
EFFECT OF REDUCING OF FWHP FOR YEARS 2003 AND 2012

Years	Liquid Rate Before lifting (STB/day)	FBH Before Lifting(Psia)	Liquid Rate After lifting (STB/day)	FBHP After Lifting (Psia)	FWHP (Psia)	Gas Injection Rate (MMSCFD)	W.C %
2003	1625	1185	1821	793	430	7.312	1
2012	1716	745	2205	334	100	1.333	0.65
2012	1716	745	2038	506	150	1333	0.65

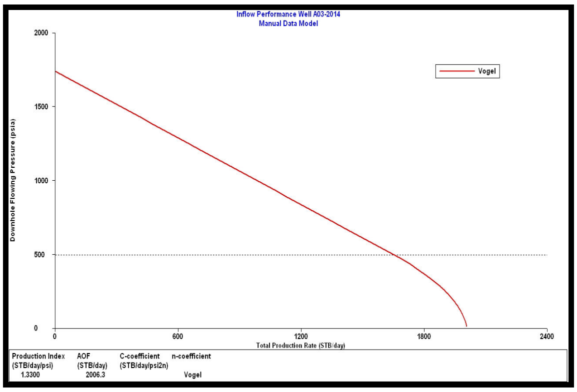

Fig. 4 Inflow Performance Curve of well A03 for year 2014

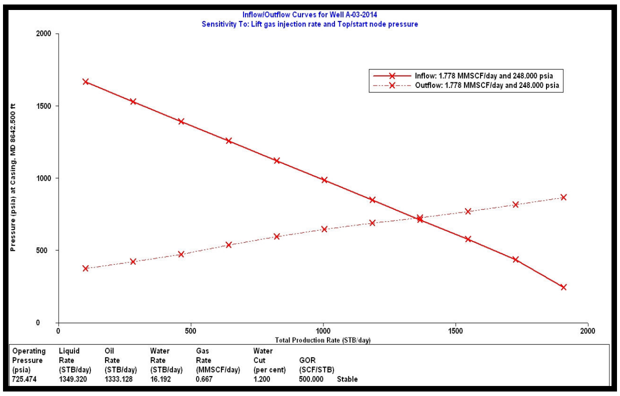

Fig. 6 Optimization lift gas injection rate of well A03 for year 2014

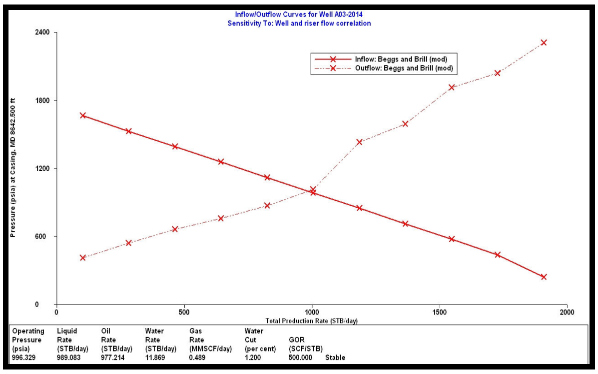

Fig. 5 Inflow/Outflow Curve of well A03 for year 2014

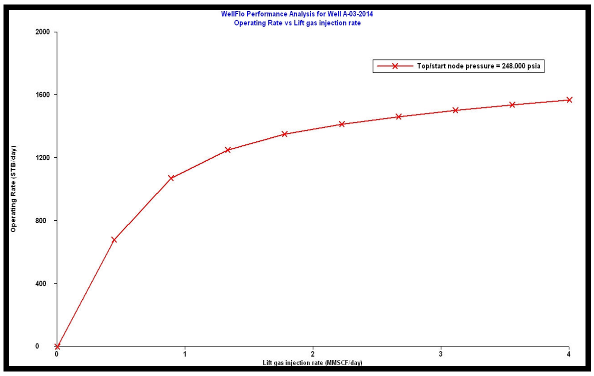

Fig. 7 Lift gas injection rate and Top/Start node pressure on Inflow/Outflow Curve of well A03 for year 2014

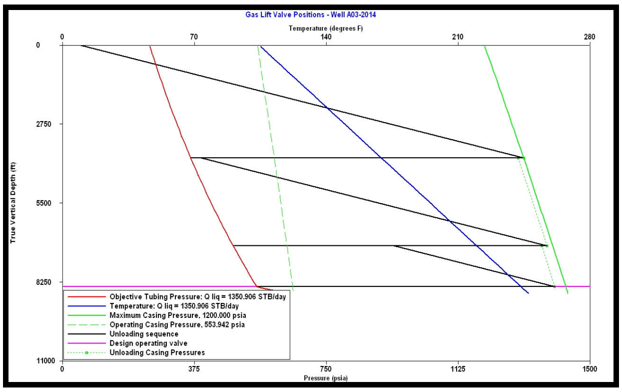

Fig. 8 Gas lift valve position of well A03 for year 2014

TABLE III
SPACING CALCULATIONS OF WELL A03 FOR YEAR 2014

Valve No.	Depth TVD	Tv (degrees F)	Port Size	R	DPc	Pt	Psc	Pd&Pvc	OP	Pso	Pd@60F	TRO	Set to	Valve Descr.	Valve Model
1	3920.7	169.1	20	0.0996	106.3	363.6	1114	1216..3	1310.6	1200	976.3	1083	1085	Gl Valve 1	1.5" IPO
2	6982.3	219.7	20	0.0996	184.1	484.5	1111	1288..3	1377..2	1186.4	949	1052	1050	Gl Valve 2	1.5" IPO
3	8400	243.2	28		99.4	551.3			651..3	551..9				Gl Valve 3	Orifice

V. CONCLUSIONS AND RECOMMENDATIONS

1. Continues flow gas lift system approved to be efficient for increasing production rates for the vertical producers covered by this study based on the available data at time of investigation.
2. Timing for gas lift systems in Wafa field is highly dependent on the average reservoir pressure at time of implementation.
3. Gas availability would not be a limiting factor for using gas lift systems in Wafa field because of in situ gas volumes and makeup gas lines connecting it with other gas sources.
4. The performance of the gas lift systems would be peaked if formation damage is removed by Halliburton Stimulation (Acidizing, Additives or Hydraulic Fracture by using PermStim™ system is a newly designed fracturing fluid system and the gel is very clean, leaving little to no residue upon breaking (< 1%), leading to improvements of well cleanup.

ACKNOWLEDGMENT

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ABBREVIATIONS

AOF	Absolute Open Flow
API	America Petroleum Institute
Btm	Bottom
D PC	Differential pressure casing
EPSE	Edinburgh Petroleum Services
FBHP	Flowing Bottom Hole Pressure
FWHP	Flowing well head pressure
G.O.R	Gas Oil Ratio
G.L	Gas Lift
IPR	Inflow Performance Relationship
KOP	Kick of Pressure
MMSCF/d	Million standard cubic feet per day
MD	Measured Depth
MPP	Mid Perforation Point
OP	Operating Pressure
Pt	Tubing Pressure
Psc	Surface Closing Pressure
Pd	Dome Pressure
Pvc	Valve Closing Pressure
Pso	Surface Opening Pressure
Perf	Perforation
PI	Productivity Index
Pwf	Bottom hole Pressure
Pr	Reservoir Pressure
PI	Productivity Index
R	Ratio between the bellows and port size area
Tbg	Tubing
TD	Total Depth
TRO	Test Rack Opening
TVD	True Vertical Depth
W.H	Well Head
WC	Water Cut
VLP	Vertical Lift Performance
OWC	Oil Water Contact
HSD	Hole Inside Diameter

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