

GSJ: Volume 5, Issue 5, May 2017, Online: ISSN 2320-9186 www.globalscientificjournal.com

GASLIFT OPTIMIZATION IN HIGHLY DEVIATED WELLS

IBE, Charles C.¹, O.F. Wopara²

FACULTY OF ENGINEERING, RIVERS STATE UNIVERSITY, NKPOLU ROWORUKWO, PORT HARCOURT

KeyWords

Gaslift, Optimization, Highly deviated, Wells.

ABSTRACT

Although gas lift technology has been applied to lift oil production in highly deviated wells increasingly, the differences between the gas lift design of deviated and vertical wells still exist. How these differences vary with the increase of the angle of inclination, which parameters are more sensitive to the design differences and how to choose the design parameters reasonably to optimize the gas lift design in the deviated wells are all always the difficulties for gas lift design reasonable in the deviated wells and few studies have been done in this field. In view of these problems, this work takes a deviated well of an oilfield as an example. According to the measured data, the optimum method for productivity prediction calculation is chosen for the design for gas lift in the deviated and vertical wells in the same conditions. By keeping other parameters constant and only changing the value of important parameter one by one, the changing regularity of gas injection depth and production with the change of inclination angles are analyzed, and the sensitivity parameters of gas lift design parameters in the deviated wells, and also provide a strong guarantee for high efficiency production. The percentage difference in oil rate between the deviated well and vertical well is 17.32%, which is on a high side. Also, the formation productivity index, PI has a percentage difference of 2.49 %, which is significant. The maximum production rate possible from a deviated well will be less than for a vertical well due to additional pressure loss at the same operating conditions. To obtain the same rate from a highly deviated well, increase either the volume of injected gas.

1 INTRODUCTION

Generally, in oil production, crude oil flows through well tubing naturally by primary oil recovery, which involves natural drive mechanisms that lift crude oil from the oil reservoir to the surface without any artificial method or aid. Nevertheless, in most cases, this primary oil recovery will not last for a long period and becomes inefficient production process. This is due to the reservoir pressure being depleted and lacking sufficient energy to lift the crude oil to the surface. Other artificial lift methods can also be used to lift crude oil to production facilities, such as electric submersible pumps (ESPs), sucker rod pumps, hydraulic pumps and gas lift methods (Schlumberger, 1999, Forero *et al.*, 1993). The gas lift method is known as an effective artificial lift technique. When bottom-hole pressure decreases, this allows the production from the reservoir to increase (Guet, 2004). The optimization of the gas lift method mainly relies on a good understanding of the reduction effects that each

599

parameter is capable of causing on the total oil production. These parameters include gas flow rate, gas injection pressure, port size, depth, gas lift valve spacing and the two-phase flow behaviors along production tubing which has a crucial phenomenon known as gas lift flow instability (Ebrahimi, 2010). Although the concept of drilling a deviated well was developed as early as 1891, with smalleycomphell patent on using a flexible shaft to rotate drill pipe, but the first recorded truly deviated horizontal well was not completed until 38 years later in Texas and the regular practice of drilling horizontal and directional wells was not achieved until early 1980s due to modern day technology. (Kaiser, J., 2007). More than half of the wells drilled in US are horizontal wells (Halliburton Completions Book, 2011). There is several artificial liftmethods used in the oil industry to maintain or supplement oil reservoir energy, such as thegas injection method, water injection method, electrical submersible pump (ESP), hydraulicpump and gas lift method. The design of any artificial lift method is largely dependent on the existing reservoir driving mechanisms. The oil reservoir driving mechanism is the ability of the reservoir to deliver fluid to the surface naturally, including gas cap solution, water drive mechanism, dissolved gas drive and a combination of all of these. Secondly, well completion should be considered in the design for a single point lift and with all modes of operation in mind. Finally, detailed attention must be paid to the stability of the gas lift, which can be achieved by understanding the unloading process and multi-phase flow behaviors in the vertical production string (Forero et al., 1993). Gas lift is one of the most common artificial lift methods used in the oil production industry. The principle of gas lift is explained by the injection of external energy such as natural gas through a casing annulus down into the tubing through subsurface gas lift valves. . The surface equipment consist of a gas source which is separated from crude oil by production facilities (production separators), and then this gas is dehydrated by a special dehydration unit or filters and then compressed to a certain pressure depending on theinjection pressure of the oil reservoir in the compressor station (Schlumberger, 1999). The gas isinjected from the surface to the casing annulus down to the well and then it enters theproduction tubing through unloading valves to lift the long accumulated fluid column above hese valves. This process is known as the kick operation. Clegg (1988) mentioned some economic factors such as: revenue, operational and investment costs as the basis for Artificial Lift selection. He believed that the selected Artificial Lift method could have the best production rate with the least value of operational costs. Ayatollahi et al., (2001) used PVT data combined with fluid and multiphase flow correlations to optimize the continuous gas lift process in Aghajari oil field. From actual pressure and temperature surveys and determining the point of injection, a gas lift performance curve was constructed. Heinze et al. (1995) used a decision tree to evaluate artificial lift selection based on a longtime economic analysis which considered primary investment, operational costs, and life time cost and energy efficiency. Moreover, continuous gas lift can also be applied to offshore fields, due to its influential water drive mechanism compared to other artificial lift methods; but this depends on the availability of gas in that particular field (Kaji et al., 2009).

2. MATERIALS AND METHODS

2.1 Materials

- 1. PROSPER Software
- 2. Production data

2.2 Design of gas lift installations

The following procedure is proposed for the design of a gas lift installation for a directional well:

1. Determine the vertical and measured tubing lengths along with the angle of deviation.

2. Calculate the pressure traverse in the directionally drilled well and transpose these pressure equivalent vertical depths.

3.Using the pressure traverses as calculated in Step 2 design the gas lift installation and illustrate the effect of deviation angle to possible flow rates and required injection gas volumes.

C GSJ

GSJ© 2022 www.globalscientificjournal.com

2.3Building and Matching the Well Model in Prosper

Building the well model in Prosper consists of modeling the physical part, PVT matching and IPR/VLP quality check. PROSPER software is built to let the user design an artificial lift method for a well based on the entered data that the user will provide, normally the artificial lift design in PROSPER is achieved after designing and matching a naturally flow single well model. In case of naturally flow wells, where matching the well parameter in its natural flow condition is the corner stone to build an accurate artificial lift design by eliminating the uncertainty when a correct matching is achieved.

2.4. Data for Vertical/DeviatedFlowing Well

Table 2.1: Fluid, Well and Reservoir Parameters

Fluid	Oil & Water	
PVT method	Black Oil	
Separator	Single-Stage Separator	
Flow Type	Tubing Flow	
Emulsions	No	
Well type	Producer	
Lift method	None	
Predicting	Pressure & Temperature (Offshore)	
Completion	Cased hole	
Gravel Pack	No	

Pressure in psig	Gas Oil Ratio	Oil FVF	Oil Visc
Table 2.3: Further PV	F data @ 260 degF	(-1)	5.1
Bubble Point Pressure	3906ps	sig @ 260 degF	
N ₂	0		
H_2S	0		
CO ₂	0		
Water Salinity	80000	ppm	
Gas Gravity	0.75 (A	Air =1)	
Oil Gravity	30 AP	I	
Solution GOR	700 sc:	f/stb	

Pressure in psig	Gas Oil Ratio	Oil FVF	Oil Viscosity
2000	317.548	1.26821	0.46018
2500	413.133	1.31	0.41103
3000	512.36	1.36	0.36816
3500	614.727	1.41	0.3314
4000	700	1.45	0.30786
4500	700	1.44	0.31945

Table 2.4: Deviation Survey Data for Deviated Well

Measured Depth in ft	True Vertical depth in ft
0	0
7500	7000
9500	8000

Table 2.5: Deviation Survey Data for Vertical Well (Assumed)

	Measured Depth in ft	True Vertical depth in ft
0		0
7500		7500
9500		9500

JJ

Table 2.6: Down-hole Equipment Data

Equipment type	Measured	Internal diame-	Roughness	Rate multiplier
	depth in ft	ter in inches		
Tubing	7500	3.068	0.0018	1
Casing	9500	6.4	0.0018	1

Table 2.7: Fluid Temperature Survey

Measured Depth in ft	Static Temperature in degF
0	50
9500	260

Table 2.8: IPR Model Selection

IPR Model	Darcy/Enter skin by hand
Static reservoir pressure	3242.8 psig
Reservoir temperature	260 degF
Water cut	25 %
Total GOR	700 scf/stb

Table 2.9: IPR Data Entry

Permeability	90 mD
Reservoir Thickness	110 ft
Drainage Area	350 Acres
Dietz Shape Factor	31.6
Wellbore Radius	0.354 ft
Skin	4
Formation Vertical Formation Anisotropy	0.1 (Fraction)
Local Vertical anisotropy	0.1 (Fraction)
Horizontal Length to Reservoir Edge	2150 ft
Vertical Depth To Top Of Reservoir (starting from origin of deviation survey)	8000 ft
Perforation Interval in Measured Depth	9500ft- 9800ft
Perforation Depth in True Vertical Depth	8000ft - 8100ft

Oil Production rate, (STB/d)	5100
Water Cut, (%)	25
WH Flowing Temperature, (°F)	50
Pressure at Christmas tree, (psia)	300
Skin (Well Test)	4
PI or J (Well Test), (STB/d/psi)	19

Table 2.11: Gas-Lift Design Parameters

Maximum gas available	10MMscf/d
Maximum gas available during unloading	10MMscf/d
Flowing top node pressure	500psig
Unload top node pressure	500psig
Operating injection pressure	2000psig
Kick-off injection pressure	2000psig
Desired dp across valve	50psig
Maximum depth of gas-lift injection	7500ft
Design water cut	50%
Static gradient of kill fluid	0.45 psi/ft
Total GOR	700 scf/stb
Design rate method	Calculated from max. Production

1000

13314 2320-9100	
Maximum liquid rate	30000stb/d
Check rate conformance with IPR	Yes
Use IPR for unloading	Yes
Orifice sizing on	Calculated dp@orifice
Vertical lift correlation	Petroleum Experts 2
Surface pipe correlation	Beggs and Brill

scf/STB Pb, Rs, Bo Glaso API Oil Viscosity Beggs et al sp. gravity				
API Oil Viscosity Beggs et al	nput Parameters		_	Correlations
API Oil Viscosity Beggs et al	Solution GOR	700	scf/STB	
	Oil Gravity	30	API	Oil Viscosity Beggs et al
ppm	Gas Gravity	0.75	sp. gravity	
	Water Salinity	80000	ppm	1
	npurities			
percent	npurities Mole Percent H2S	0	percent	
percent		J	_	
			_	
	Mole Percent H2S	J	_	
	Mole Percent H2S	0	percent	

Figure 2.1: PVT Input Data

DEVIATION SURVEY (EBELE DEVIATED WELL.Out)

Input Dat			Help	
	Measured Depth	True Vertical Depth	Cumulative Displacement	Angle
	(feet)	(feet)	(feet)	(degrees)
1	0	0	0	0
2	7500	7000	2692.58	21.0395
3	9500	8000	4424.63	60
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
Copy C	ut Paste Inse	rt Delete All	Invert Plot In	nport Export
MD <-> 1	VD		Calculati	

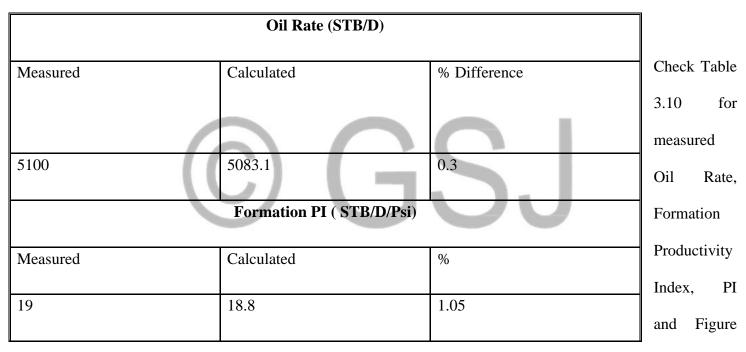
Figure 2.2 Deviation Survey for Deviated Well

3. **RESULTS AND DISCUSSION**

3.1 Model for Deviated Well

Well deliverability is determined by a well's inflow performance. The Inflow Performance Relationship (IPR) is defined as the functional relationship between the production rate and the bottom hole flowing pressure. Productivity Index (PI or J) expresses the ability of a reservoir to deliver fluids to the wellbore.

Table 3.1 Matching the Model for Well



3.1 and Figure 3.2 for IPR Plot and (VLP-IPR Match) for PI and Calculated Oil Rate respectively.

IPR Plot (C:\Users\HP\Documents\EBELE DEVIATED WELL.Out)

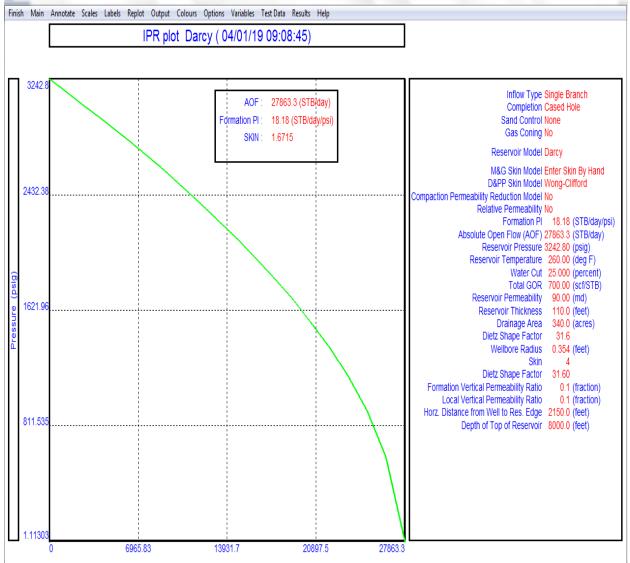


Figure 3.1: IPR Plot for Deviated Well

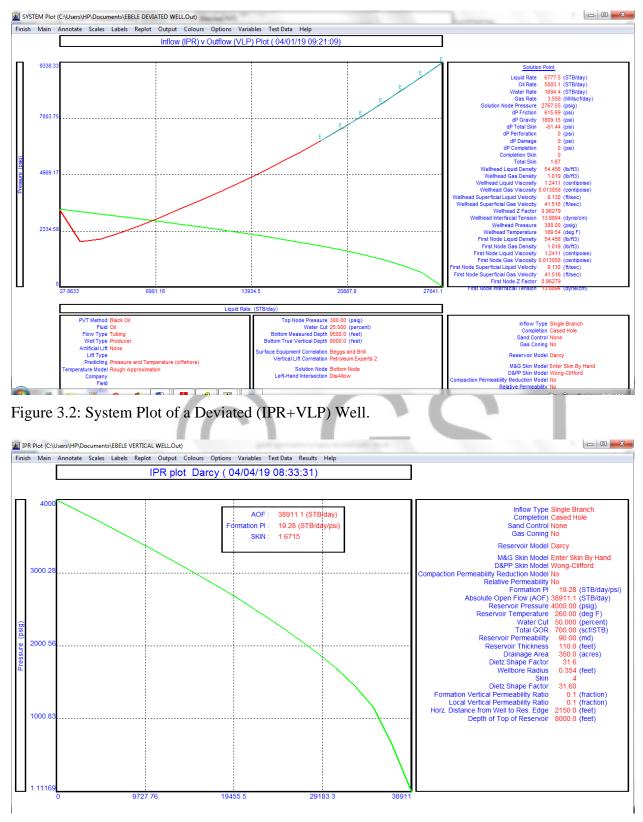


Figure 3.3: IPR Plot for Vertical Well

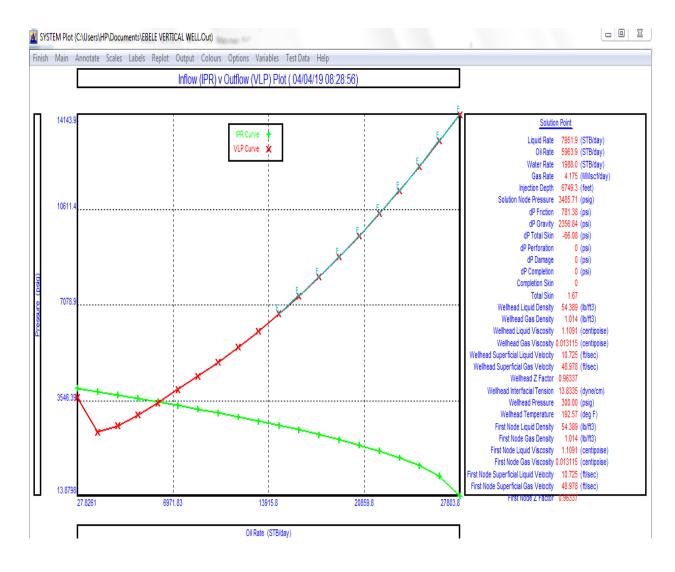


Figure 3.4: System Plot of a Vertical (IPR+VLP) Well

From Table 4.2, the percentage difference in oil rate between the deviated well and vertical well is 17.32%, which is on a high side. Also, the formation productivity index, PI has a percentage difference of 2.49 %, which is significant.

	Done Ca	ncel	Export	Re	port	Help			
In	put Data				-Gaslift D	etails			
	GasLift Gas Gravity	0.8	sp. gravity						
Γ	Mole Percent H2S	0	percent			Casing	Pressure 0	_	psig
	Mole Percent CO2	0	percent			dP Acr	oss Valve 0		psi
	Mole Percent N2	0	percent		Valve P	ositions			,
	GLR Injected	0	scf/STB		T diver	Measured		Measured	1
	Injected Gas Rate	0	MMscf/day			Depth		Depth	_
	GLR/ Rate ?	Use GLR In Use Injected				feet 3662.84	6	feet	Insert
					2	5065.23 5412.17	7		Delete
					4		9 1		All
	Gas Lift Method	Fixed Depth	of Injection pth of Injection		5		10	<u> </u>	Transfer

Figure 3.5: Gas-lift Input data for Deviated Well

Done Ca	ancel	Export	Report	Help			
out Data GasLift Gas Gravity	0.8	sp. gravity	Gas	slift Details Gaslift Valve Di	epth (Measured)	5412.17	feet
Mole Percent H2S		percent]	
Mole Percent CO2	0	percent					
Mole Percent N2	0	percent					
GLR Injected	0	scf/STB					
Injected Gas Rate	0	MMscf/day					
GLR/ Rate ?	Use GLR In Use Injected	jected d Gas Rate					

Figure 3.6: Gas-lift Input data for Deviated Well

sct/STB STB/day STB/day psig psig psig MMscf/day STB/day STB/d	Calculated Ra	ate								
537.82 7529.8 3764.9 3535.56 2991.66 2.18574 2.842 3095.1 Get Rate Plot Plot Comparison Gas Injection Pressure Temperature Gas Injection Pressure feet feet feet psig deg F psig feet psig deg F psig deg F psig feet psig feet psig deg F psig deg F psig feet psig feet psig feet psig deg F psig feet feet feet feet feet f		Liquid R	ate Oil	Uil Rate Press				Des	ign Rate	0il Production
Get Rate Plot Objective Gradient Measured Depth True Vertical Depth Pressure Temperature Gas Injection Pressure feet feet psig deg F psig 6788.7 6788.7 1405.97 'alve Number 1 @ 2965.09 (md) 2965.09 (tvd) (feet) 'alve Number 2 @ 4890.59 (md) 4990.59 (tvd) (feet) 'alve Number 3 @ 6054.32 (md) 6055.34 (tvd) (feet) 'alve Number 1 @ 2976.97 (md) 2976.97 (tvd) (feet) 'alve Number 2 @ 4918.22 (md) 4918.22 (tvd) (feet) 'alve Number 3 @ 6097.43 (md) 6097.43 (tvd) (feet) 'alve Number 4 @ 6749.33 (md) 6097.43 (tvd) (feet) 'perating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) 'perating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) Design Plot Results Main Done Help StB/day STB/day MMscf/day 3360.8 1680.4 1.993 1350	scf/STB	STB/da	y STI	B/day	psig	psig		MM	sof/day	STB/day
Objective Gradient True Vertical Depth Pressure Temperature Gas Injection Pressure feet feet psig deg F psig 6788.7 6788.7 1405.97 'alve Number 1 @ 2965.09 (md) 2965.09 (tvd) (feet) 'alve Number 2 @ 4890.59 (md) 2965.09 (tvd) (feet) 'alve Number 3 @ 6054.92 (md) 6054.32 (tvd) (feet) 'alve Number 4 @ 6695.34 (md) 6055.34 (tvd) (feet) 'alve Number 2 @ 418.22 (md) 4318.22 (tvd) (feet) 'alve Number 3 @ 6097.43 (md) 6097.43 (tvd) (feet) 'alve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) 'alve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) 'alve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) 'alve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) 'alve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) 'alve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) 'alve Number 5 @ 0.03 1.03 1.03 <td colspan="2">537.82 7529</td> <td>37</td> <td>764.9</td> <td>3535.56</td> <td>2991.66</td> <td>2.18574</td> <td colspan="2">2.842</td> <td>3095.5</td>	537.82 7529		37	764.9	3535.56	2991.66	2.18574	2.842		3095.5
Measured Depth True Vertical Depth Pressure Temperature Gas Injection Pressure feet feet psig deg F psig 6788.7 6788.7 1405.97 'alve Number 1 @ 2965.09 (md) 2965.09 (tvd) (feet) 'alve Number 2 @ 4890.59 (md) 4890.59 (tvd) (feet) 'alve Number 3 @ 6054.92 (tvd) (feet) 'alve Number 3 @ 6054.92 (md) 6695.34 (md) 6695.34 (tvd) (feet) 'alve Number 4 @ 6695.34 (md) 6695.34 (tvd) 'alve Number 2 @ 4918.22 (md) 4918.22 (tvd) (feet) 'alve Number 3 @ 6097.43 (md) 6097.43 (tvd) (feet) 'alve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) 'alve Number 4 @ 749.33 (md) 6749.33 (tvd) (feet) 'alve Number 4 @ 5749.33 (md) 6749.33 (tvd) (feet)		е		Plot						
Measured Depth Freesoure Femperature Pressure feet feet psig deg F psig 6788.7 6788.7 1405.97 /alve Number 1 @ 2965.09 (md) 2965.09 (tvd) (feet) /alve Number 2 @ 4890.59 (md) 4890.59 (tvd) (feet) /alve Number 3 @ 6054.92 (tvd) (feet) /alve Number 4 @ 6695.34 (md) 6695.34 (tvd) (feet) /alve Number 2 @ 4918.22 (md) 4918.22 (tvd) (feet) /alve Number 3 @ 6097.43 (md) 6097.43 (tvd) (feet) /alve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) /alve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) /alve Number 4 @ 5749.33 (md) 6749.33 (tvd) (feet) /alve Number 4 @ 5749.33 (md) 6749.33 (tvd) (feet) /alve Number 4 @ 5749.33 (md) 6749.33 (tvd) (feet) /alve Number 4 @ 5749.33 (md) 6749.33 (tvd) (feet) /alve Number 5 Øil Rate Injected Gas Rate Injection Pressure	Objective Gra	dient			1					
6788.7 6788.7 1405.97 'alve Number 1 @ 2965.09 (md) 2965.09 (tvd) (feet) 'alve Number 2 @ 4890.59 (md) 4890.59 (tvd) (feet) 'alve Number 3 @ 6054.92 (md) 6054.92 (tvd) (feet) 'perating Valve Number 4 @ 6695.34 (md) 6695.34 (tvd) (feet) 'alve Number 1 @ 2976.97 (md) 2976.97 (tvd) (feet) 'alve Number 2 @ 4918.22 (md) 6957.43 (tvd) (feet) 'alve Number 3 @ 6097.43 (md) 6097.43 (tvd) (feet) 'alve Number 3 @ 6097.43 (md) 6749.33 (tvd) (feet) 'alve Number 3 @ 6097.43 (md) 6749.33 (tvd) (feet) 'alve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) 'perating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) 'perating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) 'perating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) 'sesuits Main Done Help 'sesuits Main Done Help 'sesuits MMscf/day psig 's	Measured E)epth	rue Verti	cal Depth	Press	sure	Temperature			
alve Number 1 @ 2965.09 (md) 2965.09 (tvd) (feet) alve Number 2 @ 4890.59 (md) 4890.59 (tvd) (feet) alve Number 3 @ 6054.92 (md) 6054.92 (tvd) (feet) alve Number 1 @ 2976.97 (md) 2976.97 (tvd) (feet) alve Number 2 @ 4918.22 (md) 4918.22 (tvd) (feet) alve Number 3 @ 6097.43 (md) 6097.43 (tvd) (feet) perating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) perating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) Perating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) Perating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) Perating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) Perating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) Valve Number 3 @ 6097.43 (tvd) (feet) Perating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) Perating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) Valve Details	feet		fee	et	psi	ig	deg F			
alve Number 2 @ 4890.59 (md) 4890.59 (tvd) (feet) alve Number 3 @ 6054.92 (md) 6054.92 (tvd) (feet) Iperating Valve Number 4 @ 6695.34 (md) 6695.34 (tvd) (feet) alve Number 1 @ 2976.97 (md) 2976.97 (tvd) (feet) alve Number 2 @ 4918.22 (md) 4918.22 (tvd) (feet) alve Number 3 @ 6097.43 (md) 6097.43 (tvd) (feet) Iperating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) Iperating Valve Number 4 @ 6749.33 (md) 6749.33 (tvd) (feet) Results Liquid Rate Oil Rate Injected Gas Rate Injection Pressure STB/day STB/day MMscf/day psig 3360.8 1680.4 1.993 1350 Valve Details	6788.7	'	678	8.7	1405	5.97				
Results Liquid Rate Oil Rate Injected Gas Rate Injection Pressure STB/day STB/day MMscf/day psig 3360.8 1680.4 1.993 1350 Valve Details Index of the second secon	'alve Number 'alve Number Iperating Valv 'alve Number 'alve Number 'alve Number	2 @ 4890 3 @ 6054 /e Number 1 @ 2976 2 @ 4918 3 @ 6097	.59 (md) .92 (md) 4 @ 669 .97 (md) .22 (md) .43 (md)	4890.59 6054.92 5.34 (md) 2976.97 4918.22 6097.43	(tvd) (feet) (tvd) (feet) 6695.34 (tv (tvd) (feet) (tvd) (feet) (tvd) (feet)					[
Liquid Rate Oil Rate Injected Gas Rate Injection Pressure STB/day STB/day MMscf/day psig 3360.8 1680.4 1.993 1350	'alve Number 'alve Number Iperating Valv 'alve Number 'alve Number 'alve Number	2 @ 4890 3 @ 6054 /e Number 1 @ 2976 2 @ 4918 3 @ 6097	.59 (md) .92 (md) 4 @ 669 .97 (md) .22 (md) .43 (md)	4890.59 6054.92 5.34 (md) 2976.97 4918.22 6097.43	(tvd) (feet) (tvd) (feet) 6695.34 (tv (tvd) (feet) (tvd) (feet) (tvd) (feet)					
STB/day STB/day MMscf/day psig 3360.8 1680.4 1.993 1350 Valve Details	(alve Number)perating Valv (alve Number (alve Number (alve Number)perating Valv	2 @ 4890 3 @ 6054 /e Number 1 @ 2976 2 @ 4918 3 @ 6097	.59 (md) .92 (md) 4 @ 669 .97 (md) .22 (md) .43 (md) 4 @ 674	4890.59 6054.92 5.34 (md) 2976.97 4918.22 6097.43 9.33 (md)	(tvd) (feet) (tvd) (feet) 6695.34 (tv (tvd) (feet) (tvd) (feet) (tvd) (feet) 6749.33 (tv	rd) (feet)	Dor	le		Help
3360.8 1680.4 1.993 1350 Valve Details	(alve Number (alve Number)perating Valv (alve Number (alve Number (alve Number)perating Valv Design Results	2 @ 4890 3 @ 6054 re Number 1 @ 2976 2 @ 4918 3 @ 6097 re Number	.59 (md) .92 (md) 4 @ 669 .97 (md) .22 (md) .43 (md) 4 @ 674	4890.59 6054.92 2976.97 4918.22 6097.43 9.33 (md)	(tvd) (feet) (tvd) (feet) 6695.34 (tv (tvd) (feet) (tvd) (feet) (tvd) (feet) 6749.33 (tv	vd) (feet) Main		-		
	(alve Number (alve Number)perating Valv (alve Number (alve Number (alve Number (alve Number)perating Valv Design Design Results Liquid	2 @ 4890 3 @ 6054 re Number 2 @ 4918 3 @ 6097 re Number	.59 (md) .92 (md) 4 @ 669 .97 (md) .22 (md) .43 (md) 4 @ 674	4890.59 6054.92 5.34 (md) 2976.97 4918.22 6097.43 9.33 (md) 	(tvd) (feet) (tvd) (feet) 6695.34 (tv (tvd) (feet) (tvd) (feet) (tvd) (feet) 6749.33 (tv esults	rd) (feet) Main Injecte	d Gas Rate	-	Injection	Pressure
	/alve Number /alve Number /perating Valv /alve Number /alve Number /perating Valv Design Besults Liquid STB.	2 @ 4890 3 @ 6054 re Number 1 @ 2976 2 @ 4918 3 @ 6097 re Number	.59 (md) .92 (md) 4 @ 669 .97 (md) .22 (md) .43 (md) 4 @ 674	4890.59 6054.92 5.34 (md) 2976.97 4918.22 6097.43 9.33 (md) 9.33 (md) B B B B B B B B B B B B B B B B B B B	(tvd) (feet) (tvd) (feet) 6695.34 (tv (tvd) (feet) (tvd) (feet) (tvd) (feet) 6749.33 (tv esults esults ate	rd) (feet) Main Injecte	d Gas Rate	-	Injection	Pressure
Valve Type Manufacturer Type Specification	'alve Number 'alve Number Iperating Valv 'alve Number 'alve Number Iperating Valv Design Results Liquid STB. 336	2 @ 4890 3 @ 6054 re Number 1 @ 2976 2 @ 4918 3 @ 6097 re Number Mumber	.59 (md) .92 (md) 4 @ 669 .97 (md) .22 (md) .43 (md) 4 @ 674	4890.59 6054.92 5.34 (md) 2976.97 4918.22 6097.43 9.33 (md) 9.33 (md) B B B B B B B B B B B B B B B B B B B	(tvd) (feet) (tvd) (feet) 6695.34 (tv (tvd) (feet) (tvd) (feet) (tvd) (feet) 6749.33 (tv esults esults ate	rd) (feet) Main Injecte	d Gas Rate	-	Injection	Pressure

Figure 3.7: Gas-lift Input data for Vertical Well

Calculate	Plot	Sensitivity	Sensitivity Pv	D Report	Export Opt	ions Done Main		Curves Help
esults						Variables		
	Liquid Rate	Oil Rate	VLP Pressure	e IPR Pressur	e dP Total Skin	Gaslift Gas Injection Rate	3.5	▲ (MMscf/day)
	STB/day	STB/day	psig	psig	psi			
1	30.9132	23,1849	1965.81	3498	-0.25195	Solution		
2	1654.99	1241.24	1998.29	3391.76	-13.6973	Solution Details		
3	3279.07	2459.3	2304.31	3283.22	-27.5881	Liquid Rate	6325.4	STB/day
4	4903.15	3677.36	2688.75	3172.18	-41.9712	Gas Rate	3.321	MMscf/day
1 2 3 4 5 6 7	6527.23	4895.42	3127	3058.41	-56,8999	Oil Rate	4744.1	STB/day
<u> </u>	8151.31	6113.48	3584.16	2941.6	-72.4382	Water Rate	1581.4	STB/day
7	9775.39	7331.54	4036.51	2821.42	-88.6587	Solution Node Pressure	3072.54	psig
-	11399.5	8549.6	4493.56	2697.48	-105.651	Wellhead Pressure	300.00	psig
8	13023.5	9767.66	4973.13	2569.27	-123.521	Wellhead Temperature	184.23	deg F
10	14647.6	10985.7	4373.13 5460.88	2363.27	-142.398	First Node Temperature	184.23	deg F
	16271.7	12203.8	5982.01	2436.17	-162.441	Total Skin	1.67	
E 11						Total dP Skin	-55.01	psi
E 12	17895.8	13421.8	6503.56	2152	-183.85	dP Friction	748.98	psi
E 13	19519.9	14639.9	7077.37	1998.57	-206.877	dP Gravity	1991.13	psi
E 14	21143.9	15858	7659.64	1835.26	-231.853			
E 15	22768	17076	8267.59	1659.32	-259.211			
E 16	24392.1	18294.1	8899.36	1466.45	-289.546			
E <u>17</u>	26016.2	19512.1	9564.88	1249.13	-323.697			
E 18	27640.3	20730.2	10234	991.811	-362.896	Injection Depth	5412.2	feet
E 19	29264.3	21948.3	10957.4	648.108	-409.063			
E 20	30888.4	23166.3	11684.6	12.0972	-465.414			

SYSTEM 3 VARIABLES (EBELE DEVIATED WELL.Out) (Matched PVT)

Figure 3.8: Solution Details for increased Gas-lift Injection rate for Deviated Well

4. Conclusion

The maximum production rate possible from a deviated well will be less than for a vertical well due to additional pressure loss at the same operating conditions.

To obtain the same rate from a highly deviated well, increase either the volume of injected gas or operating gas pressure, or both. Where possible, use tubing flow because of the inherent additional instabilities encountered in annular flow for directional wells.

The percentage difference in oil rate between the deviated well and vertical well is 17.32%, which is on a high side. Also, the formation productivity index, PI has a percentage difference of 2.49 %, which is significant.

The design of gas lift installations in highly deviated wells can be accomplished by projecting the pressure traverses of the deviated well to equivalent vertical depths. Once this has been done, the design proceeds in the normal manner as for a vertical well. Once the projected equivalent vertical pressures are determined, the spacing of the valves can proceed in a normal manner and the proper valve can be selected. The only differences in valve design will be in port size selection, due to larger gas volume requirements of the directional wells for the same flow rate.

GSJ: Volume 10, Issue 5, May 2022 ISSN 2320-9186 Acknowledgment

My gratitude goes to my lecturers Engr Prof J.G. Akpa, Prof T.K.S Abam, Engr. Prof E.N Wami, Engr.Dr. K.K Dune, my Head of department Dr Mrs Adaobi Stephanie Anele-Nwosi, Engr. Dr. C. J. G. Nmegbu, Engr. Dr. O.F Wopara and other staff of the Petroleum Engineering Department, Rivers State University.

References

Ayatollahi, S., Bahadori, A., & Moshfeghian A., (2001): "Method optimizes Aghajari oil field gas lift," *Oil and Gas Journal*, 99(21), 47–49.

Clegg, J. D. (1988): 'High-rate artificial lift', Journal of Petroleum Technology, SPE17638, 40 (03), 277 -282.

Ebrahimi, M. (2010): "Gas lift optimization in one of Iranian South Western oil fields", Society of Petroleum Engineers.

Forero, G., Mcfadyen, K., Turner, R., Waring, B. & Steenken, E. (1993): "Artificial lift manual part 2a.

- Guet S, Ooms G, Oliemans RVA, Mudde RF. (2004): "Bubble size effect on low liquid input drift-flux parameters", *Chem. Eng. Sci.* 59:3315–29
- Heinze, L.R., Herald, W. Winkler, J. F. Lea, (1995): "Decision tree for selection of artificial lift method", *SPE 29510, SPE Production Operations Symposium*, 2-4 April, Oklahoma City.
- Kaji, R., Azzopardi, B. J. & Lucas, D. (2009):"Investigation of flow development of co-current gas-liquid vertical slug flow", *International Journal of Multiphase Flow*, 35, 335-348.

Schlumberger (1999): Gas lift design and technology.