Well Stimulation to increase Oil Production (a Case Study of Well 2L of the Shell Petroleum Development Company (SPDC) Western Operation Division in the Niger Delta, Nigeria)

Uti L. O., [#1] Asuelimen L.O., [#2] and Esabunor O. R.[#3]
[#1,2,3] *Department of Petroleum Engineering and Geosciences, Petroleum Training Institute, Effurun, Nigeria*

Abstract

In this research work, well stimulation to increase oil production was carried out. Squeeze/soaking of the reservoir was done using de-waxing solvent over-night and the acid washing of the perforation face/ soaking for 30 mins. Nitrogen was deployed to kick off the well immediately. Acidization of the reservoir was carried out using 15bbls of 10% HCl + 2.5gal 1-17A + 7gals versine -100 + 4 gals Dow-fax and 63gals WSA. Before the stimulation was performed, the CITHP and the FTHP of the well was relative low at a value of 35psi and 105 which was not producing (no flow). The no production was because of wax/ paraffin deposit across gravel-pack and perforation. In order to restore production and enhance productivity, the well was effectively stimulated using matrix acidizing method and the result from the post stimulation analysis showed an average production rate of 1628b/d. The evaluation of the stimulation treatment reveals a remarkable success.

Keywords — *Oil well, stimulation, matrix acidizing method, Otumara 2L, Production rate*

I. INTRODUCTION

The completion of some wells does not ascertain their flow to surface. Many reservoirs are so closely parched together that they do not have enough communication pores or fraction for efficient production of the reservoir fluid [1-2]. Therefore, stimulation operation is needed to either open existing channel or create new one to allow the formation fluid to flow from the reservoir to the well bore. Well stimulation treatment was originally developed to bring to life damaged or poorly producing well by creating a highly conductive path some distance away from the well bore into the formation [3]. stimulating a well in some cases before production is because of damage done to well when drilling or cementing. Presently, stimulation treatments are frequently used to initiate acceptable producing rate in both new wells and new zones in old wells. But generally, stimulation is the process by which reservoir permeability is improved to enhance productivity either by acidizing or fracturing the formation depending on the surrounding of the well bore or the types of reservoir [4]. To achieve an acceptable rate of oil production by stimulation, three principal methods are used [5] which include; Nitro- Shooting, Acidizing, and Hydraulic Fracturing.

Nitro-Shooting involved the placing of detonating of an explosive adjacent to the producing zones. Solidified or gelatin type of nitro glycerin is commonly used. The nitro-shooting is detonated with a time bomb and it is not much widely applied since the development of hydraulic fracturing [5]. Acidizing is the pumping or injection of acid into the reservoir formation. It is accomplished through fracture acidizing and matrix acidizing. Fracture acidizing involves the injection of fluid at a pressure greater than formation pressure. In this type of acidizing, the reservoir is hydraulically fractured to provide linear flow channels to the well bore. Furthermore, in matrix acidizing, the treatment fluid is injected at a pressure below the fracture of the formation with the single objective of removing any acid soluble material from the pore space. This acid soluble material may be skin damage caused by drilling [7].

Hydraulic fracture is used in the first step in low permeability reservoirs to accomplish stimulation results deep inside the formation as several hundred distances far from the well bore. But it can also be used to break through a damage zone in a high permeability well that cannot be removed by acid. The nature of the formation and the cause of problem dictates the types and composition of the acids to be used in the process, for example carbonate are often treated of skin, due to damage using hydrochloric acid (HCl) solution of stipulated strength which can create warn hole in which the insoluble damage material is dispersed. Damage caused by clay and Silicon fines in sand stone in formation can be dissolved with mud acid which is a combination of hydrochloric (HCl) and hydrofluoric (HF) acid, that is 12% to 3%HF. Hydraulic fracturing is the injection of fluid in to the reservoir formation at a pressure greater than the function gradient of the formation to break the formation for more flow of formation fluid into the well bore. However, in this research work, matrix acidizing method was adopted mainly to achieve the following research objectives; to clean out wax / paraffin deposit across gravel pack and perforation

with chemical solvent, to review the simulation method adopted on the 2L well of SPDC in Niger Delta, and to evaluate the result of the stimulation projection on the well.

II. METHODOLOGY

A. Description of Work Place

Well-2L of shell Petroleum Development Company, Nigeria was completed in October 1985 and recompleted in October1986 and was gravel packed which later came on stream in December 1986. The 2L well history reveals that wax was in the tubing in 2001 and 2002 following wax cutting of 2002, about 500 BOPD, gain was reached. The interval quit production in 2004 with HGOR. Wire line wax cutting was done in May 2005 and no wax was encountered in the tubing. It was suspected that the blockage was at the gravel pack and formation face. However, the well is presently producing about 520 BOPD with a BS & W of 0% and flowing natural pressure of 220psi [8-9].

B. Well Mechanical Data

i. SCSSV depth 150ft
ii. XN Nipple depth 7520ft
iii. End of tubing 7520ft
iv. Casing depth 8176ff
v. Length of perforation 20ft (7536 – 7556ft)
vi. Reservoir pressure 2212psi
vii. Tubing size 2 3/8”
viii. Bottom hole temp 190^{o}F

C. Production Data before Stimulation

Table 1 shows the description of reservoirs information.

TABLE 1. Reservoirs Information

Initial reservoirs pressures	4430psi
Present reservoir pressure	2212psi
Reservoir gradient	0.30 psi/ ft
Bottom hole temperature	190 deg. F

Table 2 shows the description of production data before stimulation.

TABLE 2. Production Data before Stimulation.

Date	BEAN (64)	NET Prod. BOPD	GOR SCF/STB	BS&W %	SAND 1000BBL	THP PSIG	Remark
3/01	28	704	744	0	6.9	160	
10/02	32	782	712	0	4.3	160	
1/03	36	500	437	0	5.0	160	
3/04	40	450	400	0	3.0	105	
6/05	44	200	428	0	4.0	105	

D. Equipment Load-Out

1. Coil Tubing Unit (1 ‘/2” unit)
2. Skid mounted twin Hp pump
3. 24bbl blender/power pack
4. 50bbl, 3-Compartment tank
5. 200bbl diesel resident tank
6. 100bbi flow back tank (2-compartments)
7. 2000gal nitrogen tank (3)
8. Nitrogen pumper
9. Skid mounted centrifugal pump
10. 4” suction manifold
11. High pressure low volume compressor
12. Wireline unit

TABLE 3. Materials Required for the Job

Materials	Quantity required
HCl 10%	630gal
Dow – fax	4gal
WSA-2	63gal
Vesene – 100	7gal
Soda ash	530 Ibs
Paraffin solvent	550gal
1-17A	3gal
Diesel	50 bbls
Nitrogen	100gal

E. Support Equipment

i. Chemical transfer pump
ii. Data acquisition monitor
iii. Martin Decker pressure chart recorder
iv. Centrifuge-manual
v. Hydrometers
vi. pH paper
vii. Gauges

Table 3 shows the description of materials require for the job.

F. Acid Stimulation Procedure / Job Programmed

i. During the pumping scheme, digitized recording of the pressure rate was made and CT depth.
ii. S.G of all liquid pumped into the well was measure
iii. The return fluid was monitored, and sample as required was taken.
iv. All job and any anomalies on the daily well service report was reported.

G. Front end Activities

i. The wellhead pressure was recorded and checked.
ii. Coiled tubing was flushed with clean filtered water on surface, prior to run in hole.
iii. They held safety and pre-treatment meeting with all essential personnel on location.

H. Slickline Operation

i. The slickline lubricator on well head was rigged up.
ii. They opened wellhead valve and test lubricator to CITHP.
iii. The slickline was rigged down.

I. Coiled Tubing Operations

i. The connector was made up on coiled tubing and pull test against the stripper to 10,0001b.
ii. Circulation was established through the coiled tubing and CT BHA was made up (check valve, disconnect nozzle) to CT and then CT to the wellhead was rig up.
iii. The high-pressure treatment line was pressure tested and coiled tubing to 5000 psi against the swab valve for 15minutes, BHA check valve to 1500 psi differential was tested.
iv. Back pressure was pulled back to equal 100 WHP, well was opened and RIH CT set at 20ft/min until clear of wellhead valves and DHSV, thus increase in speed to 80ft/ min, and diesel pumped at idle rate.
v. Weight check was performed every 100ft.
vi. When the CT is at 7530ftah, the pump rate was increase to maximum and wash to 7556ft then make three passes across perforation.
vii. With CT at 7550ft, they circulate the bottom up.

J. Injectivity Test/ Solvent Soak

i. The CT was lowered into the well and set at 7530ft, then 10bbls of diesel was pumped into the well at three different pumping rates, while not exceeding 4500psi CT pressure and 2100 psi well head pressure.
ii. 550 gals of solvent (70% chemical + 30% diesel) was displace with diesel to perforation and squeeze in 12bb/s into perforation.
iii. CT was cycle between 7530ft and 7550ft while squeezing the solvent.
iv. The flow back was monitored into return tank, recording rate and water cut and choke opening then the returned was pumped to flow station.
v. The pump was turned off and the well was allowed to return to its natural pressure.
vi. The coiled tubing was rigged down.
vii. The well was opened to flow station on 36/64" bean.
viii. The well was handed over to PWSN 3- OTOM.

K. Method of Treatment

a). Solvent Soak/Acid Wash

An attempt was put in place to retrieve SCSSV on the Xel nipple but none was found. This was followed with the squeeze/soaking of the reservoir with the de-waxing solvent over-night and the acid washing of the perforation face/ soaking for 30 mins. Nitrogen was deployed to kick off the process immediately. Acidization of the reservoir was carried out using 15bbls of 10% HCl + 2.5gal 1-17A + 7gals versine - 100 + 4 gals Dow-fax and 63gals WSA. Table 4 shows the description of the flow Back Analysis.

Figure 1 shows the graph of Well-2L acid job while Figure 2 shows the graph of Well-2L solvent soak job with a starting time of 11:28am and stopping time of 4:16pm.

TABLE 4. Describe the flow Back Analysis

Time	FTHP	BSW (%)	Volume (BBLS)
10/07/05 (Nitrogen Lift)			
11:40	0	No Flow	-
11:45	50	Solvent	2 6
12:15	60	Solvent	
12:30	70	Diesel+ Solvent	12
13:30	80	Diesel Solvent	19
14:30	100	Diesel+ Solvent	25
15:30	90	Contaminated Diesel	27
16:30	80	Contaminated Diesel	30
11/07/05 (Natural Flow)			
08:10	50	Acid + Crude	16
08:44	80	20%	64
9:26	150	10%	93
10:27	190	0%	143
11:48	220	0%	200

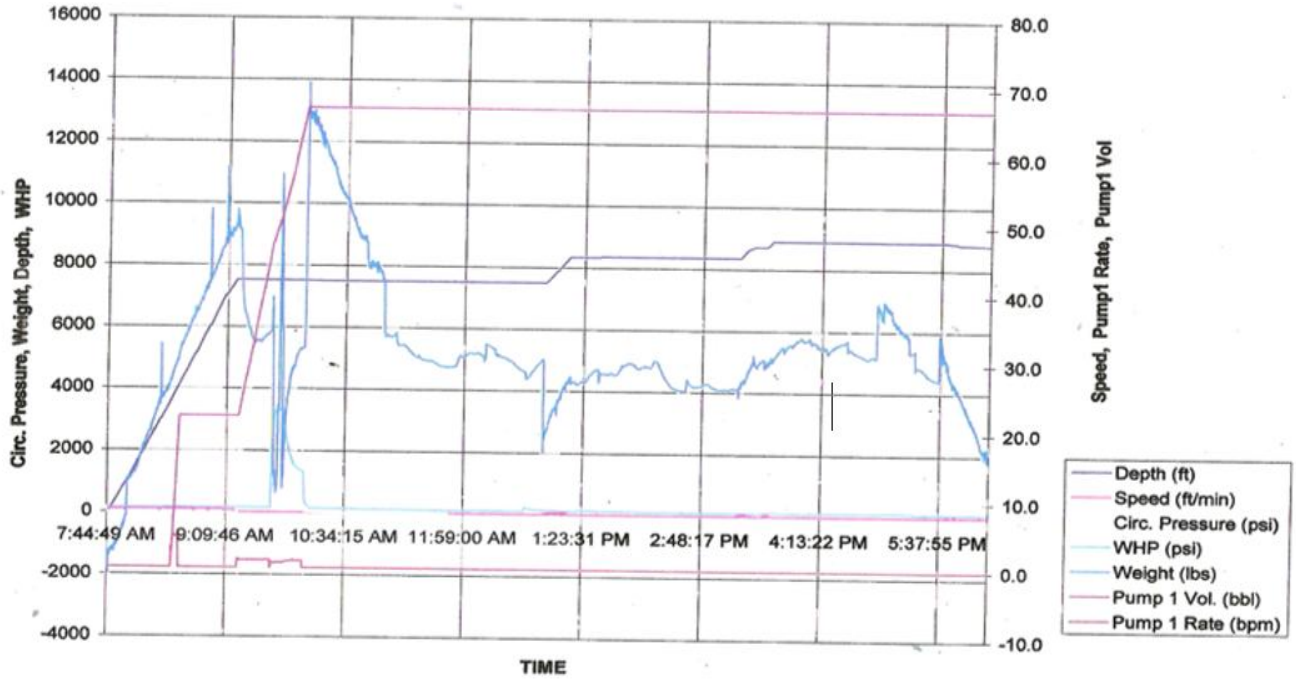

Figure 1. Graph of Well-**2L Acid Job**

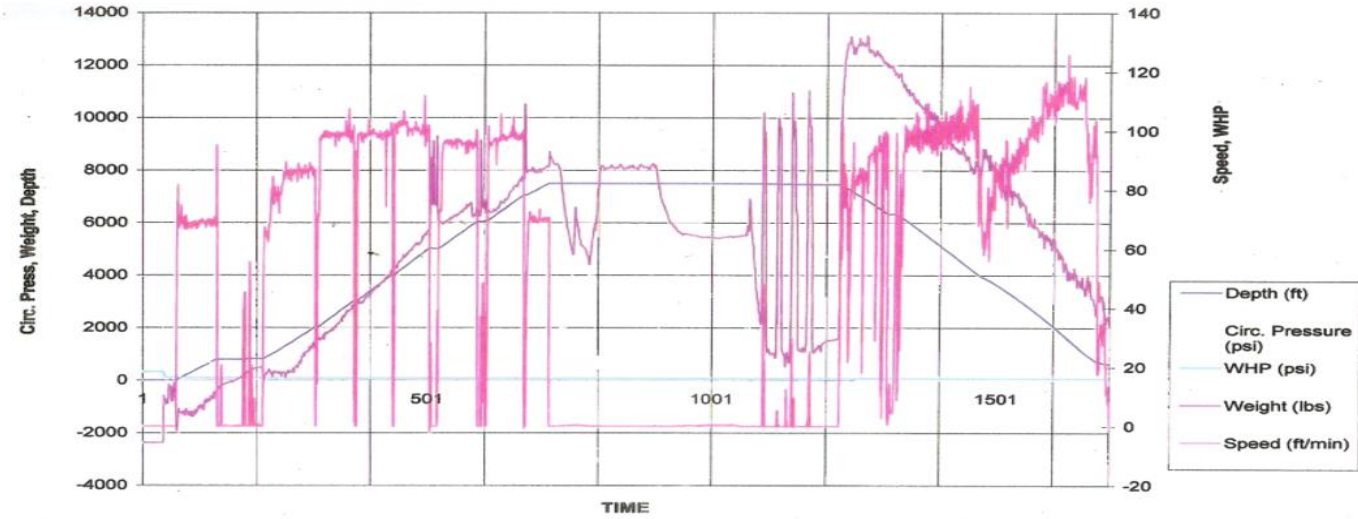

Figure 2. Graph of Well-**2L Solvent Soak Job**

III. RESULTS AND DISCUSSION

The simulation treatment was carried out smoothly after the treatment, the well was left flowing on a bean size of 36'' which now produce with an average of 520 B/D, 0 % BS & W. However, this production was higher than the proposed and expected production rate. Table 5 describes the production test data on the performance of Well-2L. To ascertain the stable patterns of the well, production tests were performed on Well-2L, after the acid stimulation job, to know the state and the effectiveness of the acid treatment from the test analysis and the results obtained is depicted in Figure 3. The result reflects that the treatment done on the well was effective. An appreciable increase in production was observed as a size of 40" bean was used. And it was recorded above proposed target of 1064b/d with a BS/W of 5% consequently. Subsequent increase in bean size to 44" recorded increased in production, an average of 1628 b/d which when compared with production before stimulation given an appreciable success of the job to this well (Well-2L).

TABLE 5. Describe the production test data on the performance of Well-**2L**

DATE	BEAN Size (64)	GROSS PROD(B/D)	BS&W (%)	GOR SCF/STB
12-7-05	36	520	0	354
19-7-05	40	1064	5	322
26-7-05	44	1628	7	291

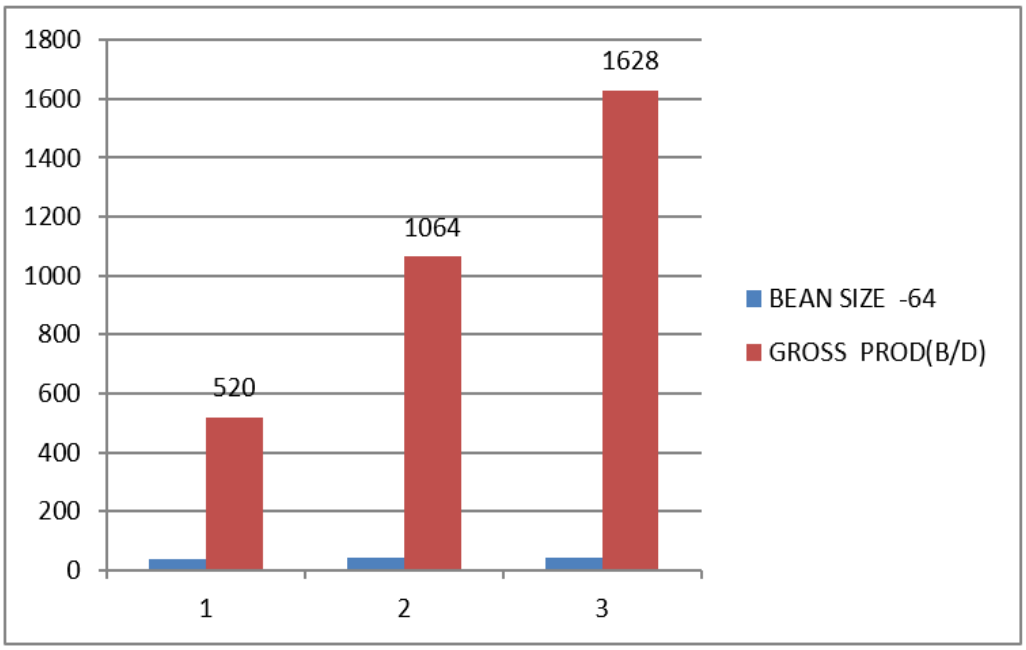

Figure 3. Graph showing the Production Test Data on the Performance of Well-**2L**

Iv. CONCLUSIONS

Having successfully carried out the research work entitled, "Well Stimulation to increase Oil Production (a Case Study of Well-2L of the Shell Petroleum Development Company (SPDC) Western Operation Division in the Niger Delta)", the results showed that the selected candidate for stimulation due to reduction in production rate of oil caused by wax/ paraffin deposited across gravel-park and perforation, causing no flow of fluid from the reservoir to well. Besides, the productivity of Well-2L was enhanced by removal of wax/paraffin through matrix acidizing method. Before stimulation, there was no production (no flow) and later after stimulation the production rate was 520 BOPD on bean size of 36/64. Then with subsequent increase in bean size of 40" and 44"/64 it now rose to 1628 BODPD.

V. RECOMMENDATION

Further research work should be carried on the well at Well-2L of the Shell Petroleum Development Company (SPDC) Western Operation Division in the Niger Delta, Nigeria) using Nitro- Shooting, and Hydraulic Fracturing.

REFERENCES

[1] C.W. Crowe. Evaluation of agent for Preventing Precipitation of Ferric Hydroxide from spent Treating acid, 1985.
[2] J.W. Ely. Stimulation treatment handbook Penn Well publishing Co. Tulsa, Oklahoma, 1985
[3] M.J. Economides, and K.G. Nolte. Reservoir Stimulation, Schaumberger Educational services, 1987
[4] W.G.F. Ford. Solvent Removes down hole NORM – contaminated $BaSO_4$ scale, "Oil and Gas, 1996
[5] University of Texas. Well stimulation treatment lesson VI, Houston Texas, 1962
[6] M.A. Mian. Petroleum Engineering hand book" (Fir practicing Engineering) Penn well publishing company, Tulsa Oklahoma, Volume 11, 2nd Edition, 1992
[7] O.A. Thomas, and P.R. Allan. Production operation "(Well completion, work over and stimulation)" Oil and Gas consultant international Inc. Tulsa Oklahoma U.S.A, Volume 11, 2nd edition, 1993
[8] Shell Petroleum Development Company. Exploration and Basic production" group training manual, 1996
[9] Shell Petroleum Development Company. Petroleum Production hand book" (SIPM) volume, 1991