Diagnosis and Control of Excessive Water Production in Niger Delta Oil Wells

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ABSTRACT

This study investigates the diagnosis and control of excessive water production in oil wells in the Niger Delta oilfields. The diagnostic plots derivatives approach was adopted. Production data were obtained from two wells and Prosper was used for the analysis. Chan's model was used for diagnosis and Water Shut-off techniques were used in control of excessive water in the case study fields. The results indicate that there is increase in production when the intervals with excessive water was shut-off and shallower intervals were perforated and monitoring of wells near terminal water-cut. The results revealed that some of the causes of excessive water production in the oil fields are channel casting leaks, open fracturing out of zones, completion in to or near water, barrier breakdown, channeling through higher permeability zones or fractures, and coning and cresting and no proper well surveillance and wells reservoir and facility management in place. For the first well NDZ_A, the initial water-cut of 60% was reduced to 0.3% with a production increase of 412 Bopd and for the second well NKZ_B of initial water-cut of 43% was reduced to 0% with a production increase of 968 Bopd. This study concludes that in hydrocarbon production, often oil produced commingled with water. As long as the water production rate is below the economic level of water/oil ratio (WOR), no water shut-off treatment is needed. Problems arise when water production rate exceeds the WOR economic level, producing no or little oil with it. Therefore, it is necessary that effective evaluation of the intervention procedure is carried out and expected outcome using the production performance data should be encouraged.

Keywords : Excessive water, Diagnosis, Control, Niger Delta, Oilfields, oilwells

1 INTRODUCTION

Water production is a common occurrence during oil and gas production when the well is aging. This may be cause by coning, density and pressure differences and perforation interval during completion. Excessive water production can increase corrosion rate of pipes if it is sour crude (Crude oil with some percentage of hydrogen sulphide, and other minor constituents). Water production was reported approximately twenty-one (21) billion barrels annually compared to oil of one billion nine hundred million barrels (1.9 billion barrels) and gas of twenty three trillion nine hundred billion cubic feet (23.9 TCF) (Veil, 2009) . The problem of water production is applicable to all forms of oil wells (Joseph & Ajienka, 2010).

It has been identified that excessive water production during oil production in oilfields has negative economic implications for E&P oil companies. One of these implications is that it affects the performance of producing oil wells and reduces their lifespan. Also, water in the wellbore increases the bulk of the fluid column and this always leads to an increase in the requirements to be met in lifting of hydrocarbons. This further influences the operating cost and lowers the drawdown. In a gas well and in a situation where the water production is excessive, it requires higher gas injection in the well in order to lift the gas from the wellbore to the surface (Ahmed, *et al.*, 2012).

One of the key problems of excessive water production during oil production in oilfields is the cost of separating, treating, and disposing the water. This has a toll on the budget of oil exploration and production (E&P) companies. For example, in Alberta, it cost about 1 million US dollars in a year to dispose excessive water. To get rid of this excessive water, Permana *et al* (2015) feel that it will decrease the costs of operations and inversely increases profitability in business (Thomas *et al.,* 2000). For this reason, (McIntyre *et al*,1999) posit that it is very important that water shutoff should be applied to manage and control the excessive water in the oilfields.

In a global oil production, water shutoff is the best technic to manage and, in some cases,, avoid excessive water production in oilfields (Mahgoup & Khairb, 2015). Liu *et al*., (2012) as cited in Mahjoup (2015) did a study on the effect of the foam agent solution in the shutoff technique in order to determine the workability of the application of nitrogen foam to control excessive water. They establish the use of numerical simulation by the use of foam into a horizontal well and 3 vertical wells. The result of their study shows a considerable improvement in the control of water in a horizontal well but the shut-off technique was not successful in the vertical wells tested. Bailey *et al*., (2000) & Seright *et al*., (2003) in their contributions explain that some oil E&P companies experiment the application of water shutoff technique without the process of use of diagnostic procedures which made it not successful. However, Chou *et al.,* (1994) added that there is always communication between injection well and production well in the water shutoff technique and that the technique should involve diagnostic procedure(kabir,2001).The cost of handling the water ranges from 5 to 50 cents, where this cost is a function of the water cut (Bailey *et al.,* 2000). It is therefore imperative that actions be taken to reduce this adverse effect, as this will not just lead to potential savings, but its greatest values come from potential increase in oil production and recovery. To control the produced water effectively, the source or the mechanism of the water problem must be identified (Alexis, 2010). Diagnostic plots have been used successfully to pinpoint the mechanism and dynamics of excessive water production in oilfield and that is the focus of

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this work.In oil and gas industry, excessive water production is a multifaceted issue especially in mature oilfields. In fact, there are adverse impacts on the economy and environment. The argument by some operators in the industry is that the industry has two outputs namely, oil and water. To this effect, some control mechanism needs to be put in place to evaluate the water production and proffer ways of solving the problem (Mahgoupa & Khairb, 2015). And one major challenge the oil and gas industry are confronted with is how to manage the excessive water, which is unproductive.Prosper diagnosis model is important for enriching successful application of the traditional treatments of water production which may be technically and commercially viable in the industry (Abass & Merghan, 2011). Diagnostic Plots derivative approach was proposed as a theorical model for the control and treatment of excessive water production in oil and gas wells (Chan, 1995). This technique which is a log-log Plot of WOR versus time or GOR versus time was proven to be the most appropriate way of identifying source of water production problems (Alexis, 2010). The application of WOR Plots for vertical and horizontal wells, a diagnostic derivative method of water production problem was considered a unique , and inexpensive method of identifying excessive water production (Abass &Merghan, 2011, Al Hassani et al; 2008).

In the Niger Delta, there are over 78 oilfields. Some oil exploration and production (E&P) companies operating the region have made efforts for treating and controlling water to meet the standards and the minimum environmental safety for handling excessive water production in these oilfields. This study investigates excessive water production diagnosis and control in the Niger Delta Oil Fields, using WOR derivative and water shut off method.

2 METHODOLOGY

Production data were obtained from field X & Z for diagnosing the problem of excessive water production.

2.1 Method of Diagnosing Excessive Water Production

Chan's model used as water control diagnostic plot derivative was adopted for the diagnosis. In the process , a cost /environmental scale will be developed in order to create guidelines for operators for better operating , maintenance , optimization and effectively environmental friendly strategy. The flow chart for the excessive production diagnosis and intervention process investigation is presented in Figure 1. The well diagnostic process analysis are shown in Figure 2 & 3.

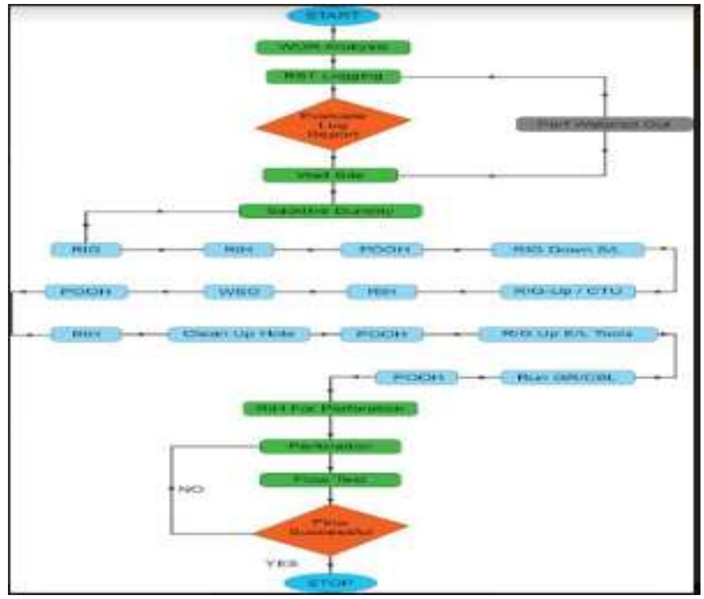

Figure 1: Flow chart for the investigation of excessive water production wells and intervention process

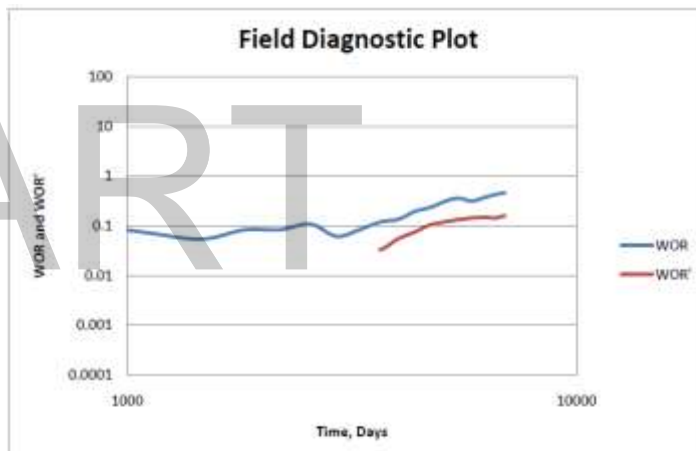

Figure 2: Field Diagnostic Plot

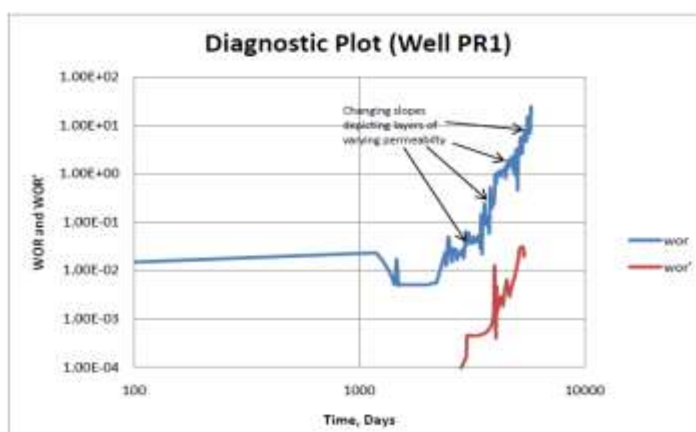

Figure 3: Well Diagnostic Plot (Well PR1)

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The key optimum way for water control, is the diagnostics to identify the specific water problem at hand. Well diagnostics are used in three ways:

i. Screening wells that are suitable candidates for water control.
ii. Determine the water problem so that a suitable water-control method can be selected.
iii. Locate the water entry point in the well so that a treatment can be correctly placed..

3 RESULTS AND DISCUSSION

3.1 NDZ_A Oil- Water Diagnostic Analysis

The water analysis carried out on the cause of increasing BSW on the oil well suggests a natural water encroachment (rise in OWC contact) indicated by the trend of Chan's water diagnostic plot for NDZ_A well as shown Figure 4. The rise in OWC is as result of drawdown of increased choke from 16(/64") to 40(/64") bean size. Similarly, the reservoir correlation plot (Figure .3) through NDZ_A shows that the water invading the perforation zone is edge water.

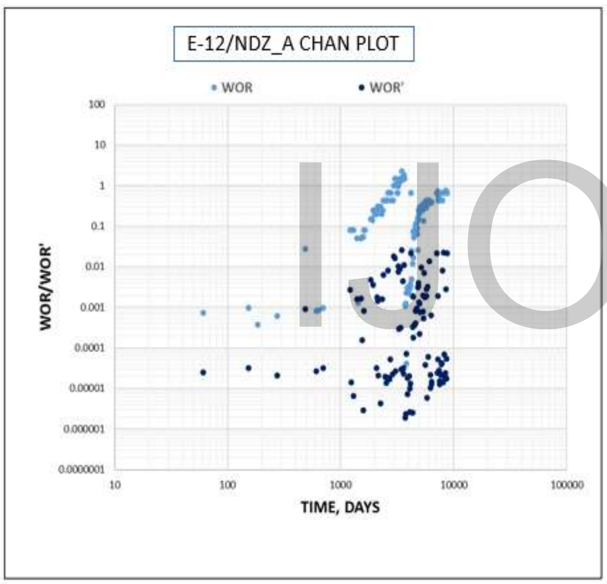
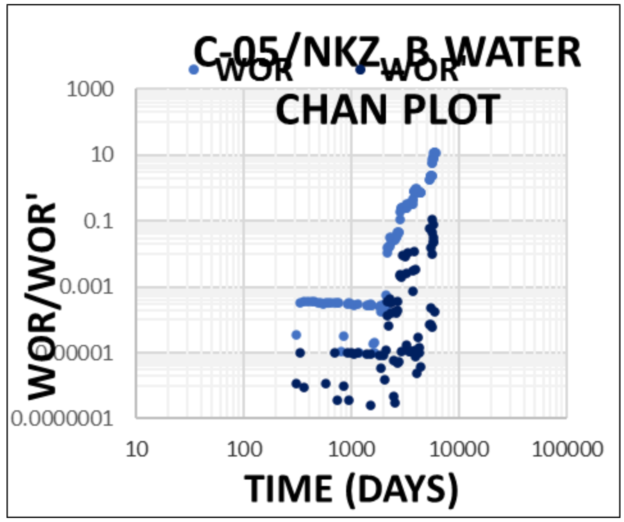


Figure 4: E-12/NDZ_A Chan Plot

3.2 C-05/NKZ_B Well Water Diagnostic Analysis

The water analysis carried out on the cause of increasing BSW suggests a natural water encroachment (rise in OWC contact) as indicated by the trend of Chan's water diagnostic plot for NKZ_B well as shown in Figure 5 for water diagnostic plot. The rise in OWC is as result of drawdown on a choke of 32(/64") bean size.



Figur 5: C-05/NKZ_B Water Chan Plot

3.3 Pre-Water Shut-off and Post-Water shut-off Analysis

Wells NDZ_A and NKZ_B have been selected as candididates for water shut-off workover operations. Water analyses of both wells using Chan's diagnostic method suggests natural water encroachment. Further analyses indicates the original perforation intervals were partly flushed, hence the reason for high BS&W (water cut). However, RST log results shows opportunity for crestal re-perforation in both wells. The comparative result of the pre-water shut off and post-water shut off oil and water-cut production is presented in Table 1 and Figures 6 and 7. Also, the candidate wells' RST logs are presented in Figures 8 and 9.

Table 1. Pre-Water and Post-Water Shut-off

Well	Pre water shut off				Post water shut off				
	Shut-off date	Perforation interval (ft)	Water cut (%)	Oil rate (bopd)	Date re-opened	Perforation interval (ft)	Water cut (%)	Oil rate (bopd)	Oil gain (bopd)
E-12/NDZ_A	Aug-94	12854-12860	60	112	Sep-94	12794-12820	0.3	524	412
C-05/NKZ_B	Nov-05	10059-100099	43	107	Dec-05	10025-10044	0	1075	968

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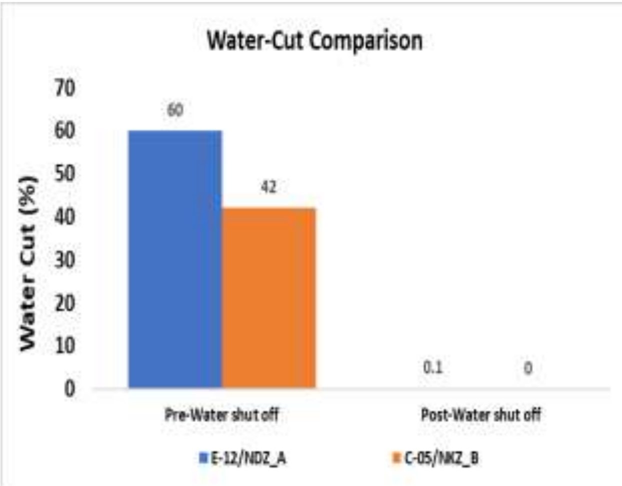

Figure 6: Water-cut Comparison Pre & Post Workover

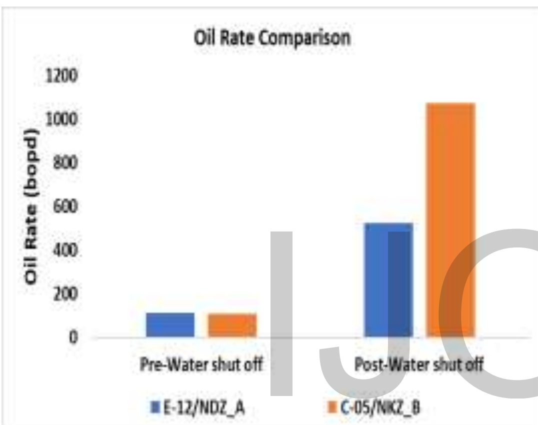

Figure 7: Water-cut Comparison Pre & Post Workover

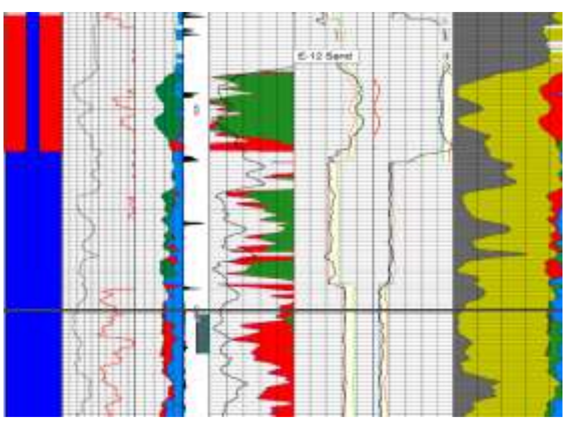

Figure 8: Carbon/Oxgen (C/O) Log for NDZ_A Well

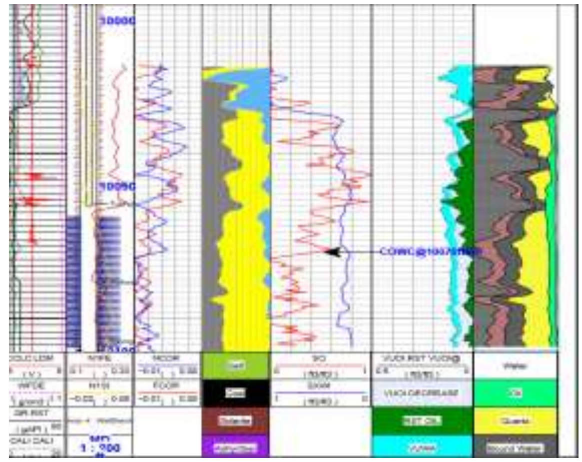

Figure 9: Carbon/Oxgen (C/O) Log for NKZ_B Well

3.4 Post-Workover Water-Cut Sensitivity

The PETEX PROSPER well modeling software was utilized to develop well models using the reservoirs PVT data as well as the individual well data. The vertical flow performance tables were generated by first modeling the reservoir IPR; choosing an appropriate vertical lift correlation for the bottom hole pressure and sensitizing on water-cut to determine the post-workover limiting water-cut for both wells. The operating THP was assumed to reduce as the average reservoir pressure reduces and water-cut increases while the test data was used to calibrate the models before sensitivity.The THP and the average reservoir pressure data as well as terminal water-cut of 89% for NDZ_A and 95% FOR NKZ_B wells as the results are tabulated in Table 2 while the water-cut sensitivity plots are presented in Figures 10 and 11.

Table 2: Post-Water Shut-off Water-Cut Sensitivity

Wells	Oil Rate(Bopd)	Gas Rate(Sc/day)	Water Rate (stb/day)	FBHP Psia	WHT Deg.F	THP (Psia)	BS & W (%)	Total Liquid (stb/day)
NDZ_A	287	676	2107	4726	148	400	89	2394
NKZ_B	138	156	2154	3974	123	250	95	2291

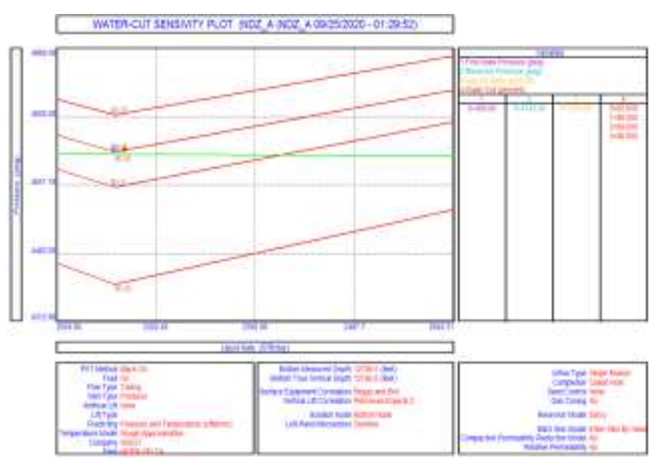

Figure 10: Water-Cut Sensitivity Plot for NDZ_A_ Well

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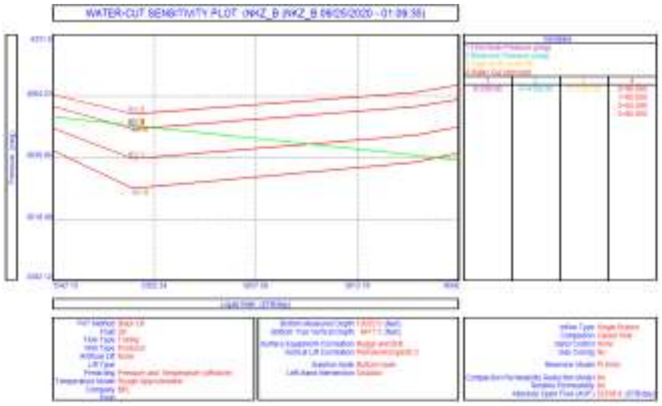

Figure 11: Water-Cut Sensitivity Plot for NKZ_B Well

4 CONCLUSION

This study has investigated excessive water production diagnosis and control in oilfields in the Niger Delta, using WOR derivative diagnostic methods and subsequent water shut-off for oil gain opportunity. Effective water diagnostic which considers all data; static to dynamic data is key to an effective and positive well intervention in the oil fields.

The diagnosis reveals major factors causing excessive production as channel casting leaks, open fracturing out of zones, completion in to or near water, barrier breakdown, channeling through higher permeability zones or fractures, and coning and cresting. After water shut-off , the production of oil increases for both well investigated with water cut reduces to less than 1%. Effective evaluation of the intervention procedure as the monitoring of the process and expected outcome using production performance data should be ensured as an effective and positive well water-shut off in the oilfields. The use of Carbon/Oxygen log to compare whether the perforation intervals have been watered out or not and fluid contacts has been moved or not before carrying out any water shut-off exercise should be encouraged by practitioners in the field.

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