EVALUATION OF TERMINAL WATER-CUT OF EXCESS WATER PRODUCING OIL WELLS IN THE NIGER DELTA OILFIELDS

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ABSTRACT

This paper evaluates the terminal Water-Cut of selected Oil Wells in the Niger Delta Oilfields using the Prosper software to run sensitivity to determine the natural flowing limit of bottom Sediment and Sand (BS&W). It covers the understanding of the water production mechanism which causes excess water production problems. Evaluation was done with PVT data, Well deviation Survey data, Well completion schematics, flow test data all inputted in the Prosper tool with different correlations .The post water shut sensitivity analysis shows that at 88% the oil production rate for NDZ_A was 287 Bopd with gas rate of 676scf/day and water rate of 2107stb/day while NKZ_B well indicates that at 94% the oil production rate was 138Bopd with gas rate of 156scf/day and water rate of 2154 stb/day. The results shows different percentage of Water-cut when sensitivities were run, which is the limit the well will stop flowing or produce oil. The importance of the Model is its quick in resolving issues and proper well reservoir and facility management. The use of prosper software is accurate if the data's inputted are correct and current.

Keywords: Water -cut, Prosper Model, Sensitivity and Niger Delta Oil wells.

1.0 INTRODUCTION

The ratio of water produced compared to the volume of total liquid produced must be determined in excessive water producing oil wells of the Niger Delta oilfields. This is one of the most important drives for oil production since it is of great assistance to management of reservoirs, mobilizing the oil, and displacing it in the homogenous rocks (Taha&Amani, 2019). According to Joseph and Ajienka(2010), It is the water produced at a low water/oil ratio (WOR) which maintains the profitably of a production well. Water shutoff operations focus on eliminating unwanted water production, which is also called 'bad water'. This kind of production creates problems other than those mentioned previously, such as reduced oil production and poor sweep efficiency within the matrix rocks.

In oil and gas industry, excessive water production is a multifaceted issue especially in mature oilfields. However, there are some 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 end, some control mechanism needs to be put in place to determine the water production and proffer ways of solving the problem (Mahgoupa&Khairb, 2015). In order to reduce the excessive water production, water shutoff technique both mechanical and chemical, and other procedures have always been applied (Joseph &Ajienka, 2010).

Water is produced in to the well due to many different causes. Water production can be related to mechanical problems, poor completion procedures or reservoir conditions. The main obstacle in the management of water production studies is the correct diagnosis of the nature

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and the origin of the problems. Each problem type requires a different approach to control and treat the problem effectively. In reality, an oil well can experience a combination of different problem types. However, reservoir related problems of coning and channelling through high permeability layers are more challenging to diagnose and treat (Seright*et al.*, 2003). The water produced in to the well bore comingled with oil at an economic water/oil (WOR) ratio is an accepted fact in the oil industry as it cannot be reduced or shut off without affecting the oil production. Problems arise when water flows in to the oil well at a rate exceeding the economic WOR limit, producing little or no oil. The cost of handling and disposing this unwanted water could have a negative impact on the economic life of the oil well. It is estimated that on average oil companies produce three barrels of water for each barrel of oil, which entails a staggering cost of US$ 30-40 billion worldwide (Du *et al.,* 2005).Several analytical and empirical techniques using information such as production data, water/oil ratio and logging measurements have been developed to determine the type of water production problem, locating the water entry point in the well and choosing the candidate wells to perform treatment methods. (Seright, 1998).The challenge on determination of water-cut terminal of excessive water producing oil wells of the Niger Delta oilfields informed this study.In petroleum production, a certain amount of water production is expected and sometimes even necessary in the initial phases of the life of the reservoir or well. A petroleum engineer will have to be able to decide when water control solutions should be applied. If the costs associated with a water production rate still allow for an acceptable operating profit from produced oil or gas, that water production rate is considered acceptable. If the costs associated with a water production rate are too high to allow for an acceptable operating profit margin, the water rate is considered excessive (Mohamed *et al*., 2014).

Excessive water production is one of the common and challenging problems associated with hydrocarbon production. Reservoir rocks normally contain both petroleum hydrocarbons and connate water. Once the production starts, this water called connate water is also produced into the wellbore comingled with oil. In addition to the connate water contained in reservoir rocks, many petroleum reservoirs are bounded by or are adjacent to large aquifers. These aquifers can provide the natural drive for petroleum production. Once the aquifer pressure is depleted, additional water is also injected into the reservoir to provide further pressure to the hydrocarbon reserves to move towards the production wells. Water from these various sources can flow into the wellbore and co-produced with the hydrocarbon stream. Such water is referred to as produced water. The ratio of produced water to the produced oil is denoted as WOR (water/oil ratio). The WOR economic limit is where the cost of handling and disposal of the produced water approaches the value of the produced oil (Rabiei, 2011).Water is produced in to the well due to many different causes. Water production can be related to mechanical problems, poor completion procedures or reservoir conditions. The main obstacle in the management of water production studies is the correct diagnosis of the nature and the origin of the problems. Each problem type requires a different approach to control and treat the problem effectively. In reality, an oil well can experience a combination of different problem types. However, reservoir related problems of coning and channelling through high permeability layers are more challenging to diagnose and treat (Seright *et al.,* 2003). The water produced in to the well bore comingled with oil at an economic water/oil (WOR) ratio is an accepted fact in the oil industry as it cannot be reduced or shut off without affecting the oil production. Problems arise when water flows in to the oil well at a rate exceeding the economic WOR limit, producing little or no oil. The cost of handling and disposing this unwanted water could have a negative impact on the economic life of the oil well. It is estimated that on average oil companies produce three barrels of water for each barrel of oil, which entails a staggering cost of US$ 30-40 billion worldwide (Du *et al.,* 2005).Several analytical and empirical techniques using information such

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as production data, water/oil ratio and logging measurements have been developed to determine the type of water production problem, locating the water entry point in the well and choosing the candidate wells to perform treatment methods. Water/oil ratio diagnostic plots are probably the most widely used technique in reservoir performance studies. Many oil companies to date rely on log/log plots of WOR and its derivative against time to identify WPMs caused by water coning or channelling (Al Hasani *et al.*, 2008). WOR diagnostic plots are easy to use and explicable for non-experts. The production data required for these plots are routinely collected and accuracy of these data is usually reliable. Nevertheless, without taking other important reservoir parameters in to account, the WOR diagnostic plots could easily be misinterpreted and it has been demonstrated that applying these plots on their own could be misleading (Seright, 1998; Rabiei *et al*., 2009).

2.0 METHODOLOGY

Schematic Flow Chart

The flow chart in Figure 1 indicates the procedures of accomplishing the process of gradient matching and sensitivity analysis study. It shows the steps to input the required reservoir and well data, flowing pressure survey data, etc. in PROSPER.

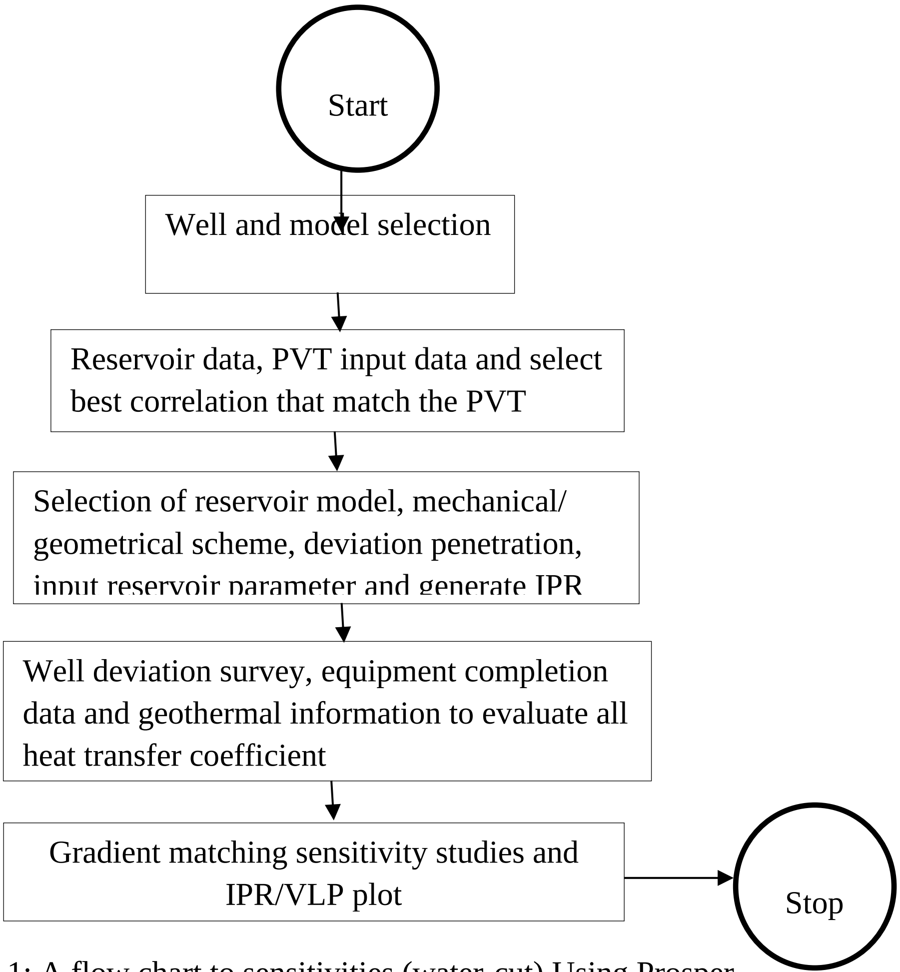

Figure 1: A flow chart to sensitivities (water-cut) Using Prosper

Prosper Data Input Workflow: The Prosper software main screen is divided into 5 sections:

1. OptionsSection
2. PVT Sections
3. Equipments Data Section
4. IPR Data Section

5. Calculation Summary Section.

Prosper Model Setting up: Starting up the Prosper program begins with defining the model in the option section of the screen. In this section you make the following specifications:

i.	Fluid:	Oil and Water
ii.	PVT Method:	Black oil
iii.	Lift Method:	Naturally Flowing Well
iv.	Predicting:	Pressure and Temperature (Offshore)
v.	Completion:	Cased Hole

PVT Section: The following steps and datas were required

i. Enter the PVT Black Oil model and input GOR, Oil gravity,Gas graviy and Water Salinity
ii. Enter PVT match data and input Temperature, Bubble Ponit Pressure, Reservoir Pressure, Oil FVF, Oil Viscosity
iii. Match the PVT Black Oil correlation to the PVT match data entered and select the best correlation.

IPR Data Input Section: In this section begins by selecting the Reservoir model(Darcy, Vogel, PI Entry, Composite, Jones etc.) and enter the following; Mechanical/Geommetrical Skin, Reservoir Pressure, Reservoir Tempresure, Water cut and Relative Permeability and click on the right button of the window and input the following data; Reservoir Permeability, Reservoir Thickness, Drainage Area, Dietz Factor and Wellbore Radius. Then validate and calculate to supply the IPR Plot.

Equipment Data Section: In this section the well deviation survey, the completion and geothermal informations are required to model to evaluate all heat transfer coefficent and accept the default values for heat capacities.

Calculation Summary Section: This section is matching the model to a test data for existing wells and new wells enter system 3 variablesand imposed assumed Top Node Pressure (THP), GOR, select surface equipment correlation , vertical lift correlation, solution node, rate method ,left Hand intersection must be disallowed and click continue, continue to stimulate GOR, Water cut, Reservoir Pressure sensitivity which is the natural flowing limit. Existing Wells matching process consist of two main steps, matching of VLP and VLP/IPR (Quality Check) by entering the well test data, compare the multiphase flow correlations (QC) and select the best correlation, estimate U Value a new overall heat coefficient will be calculated and update the U value. After matching , perform a system analysis and run sensitivities . then generate VLP curve for simulators by clicking VLP(tubing curves) 3 variables which generate vertical lift curves which will exported to MBAL model for reservoir predictions etc.

Natural Flowing Limit: This is a terminal water-cut of wells making excessive water will stop flowing in natural limiting condition and production constrains. These include minimum THP assumed or imposed, 3 Rsi (3 times initial solution GOR) and abandonement reservoir pressure usually gotten from MBAL or reservoir pressure sensitivity on Prosper. This determine the percentage of BS&W the well will stop flowing.

3.0 RESULTS AND DISCUSSION

Sensitivity Analysis

Before starting the sensitivity analysis, IPR/VLP matching is required in order to tune the wellbore multiphase flow correlation to fit with bottomhole flowing pressure (real condition) using the well test data. This allows us to check the consistency of VLP. PROSPER is able to

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calculate the VLP for a range of flow rates and pressure values at the sandface for each of the active test points that have been entered into the VLP Matching segment. IPR may or may not need to adjust to match the measured data, depending on the percentage difference in calculated liquid rate and bottomhole pressure with the measured data

Post-Workover Water-Cut Sensitivity Analysis

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 as presented in figure 2 and 3; 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 88% for NDZ_A and 94% FOR NKZ_B wells as the results are tabulated in Table1 while the water-cut sensitivity plots are presented in Figures 4 and 5.

Table 1: 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	88	2394
NKZ_B	138	156	2154	3974	123	250	94	2291

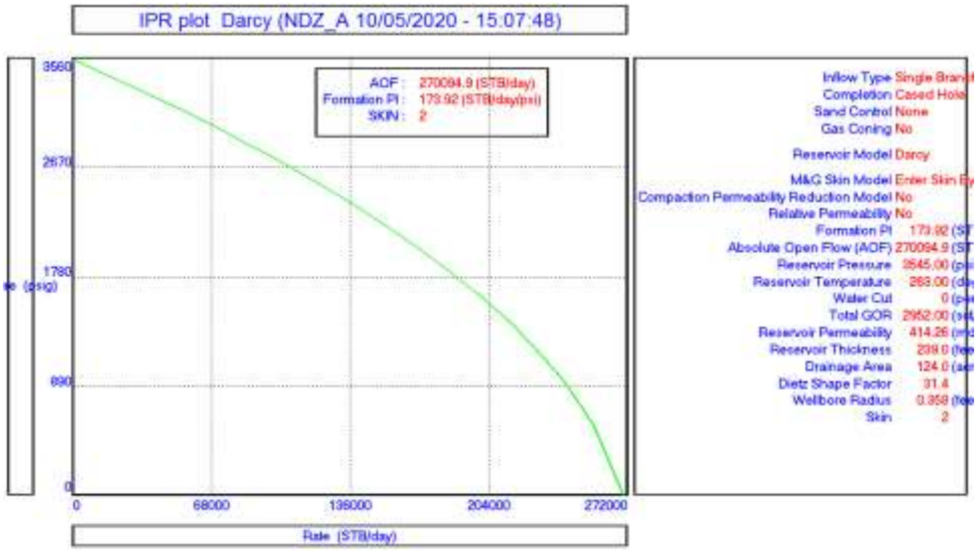

Figure 2:Inflow Performance RelationsPlot for NKZ_BWell

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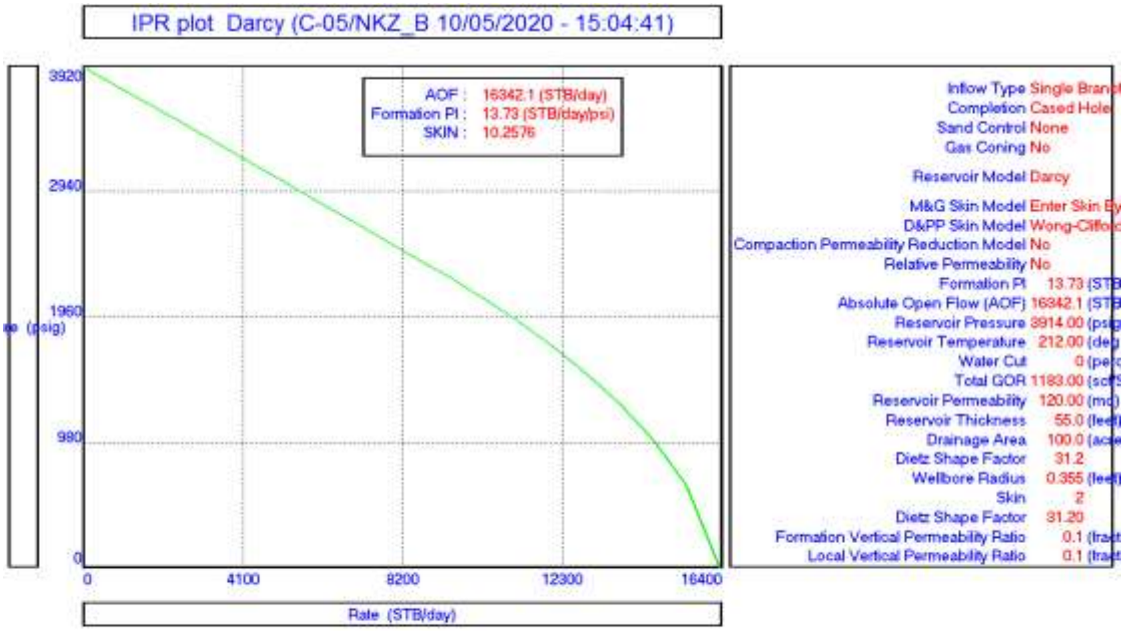

Figure 3: Inflow Performance Relations Plot for NKZ_BWell

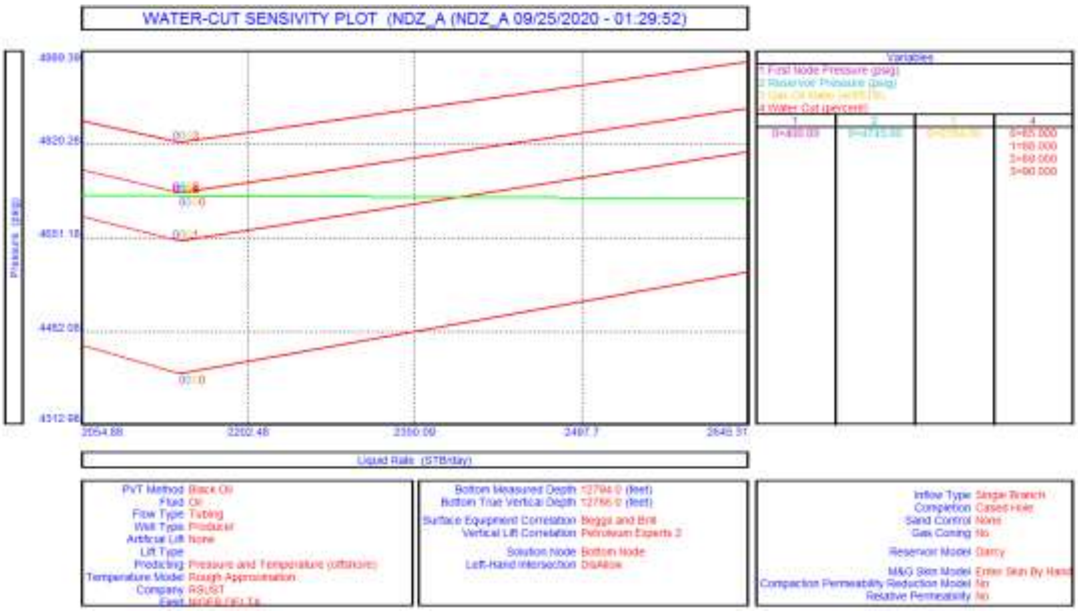

Figure 4. Water-Cut Sensitivity Plot for NDZ_A_ Well

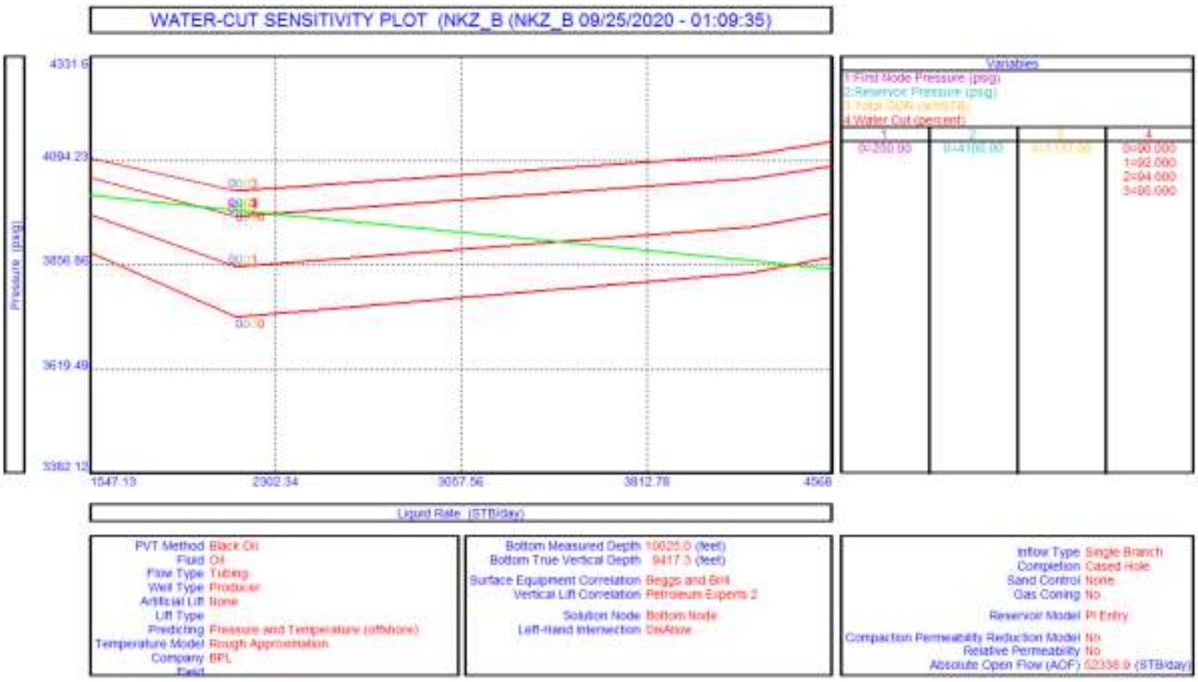

Figure 5: Water-Cut Sensitivity Plot for NKZ_BWell

CONCLUSIONS

Based on the analysis carried out. However, the following conclusion were drawn

1. The analysis reveals that water cut keep increasing above 80% in both wells
2. Terminal water-cut was determined and it indicated the percentage of water-cut of 88 and 94% which the well or string will stop flowing.
3. Increment of water cut affects both IPR and VLP curves. From 0% and above 50 % water cut, it increases the AOF of IPR curves and enhances the production rate . However, the water influx also increases gradually.

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