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Research Article

Study of the Performance of the Upper Pinda Hydrocarbon Reservoir in the Drainage Radius of the lukami-02 Well in Applying the Fetkovich Method

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Abstract

The objective of this study is to evaluate the performance of the Pinda Superior hydrocarbon reservoir, more specifically in the area of influence of the Lukami-02 well. To do this, we applied the Fetkovich method, an analytical tool widely recognized in the oil industry, to characterize reservoirs and assess their production potential. The Fetkovich method allows us to establish a relationship between the production rate of a well and the pressure inside the reservoir.

Keywords: reservoir performance, upper pinda, drainage radius, Fetkovich method

1. Introduction

Hydrocarbon reservoirs are complex systems whose understanding is essential for efficient operation. In this context, this study focuses on the Pinda Upper reservoir and more specifically on the Lukami-02 well. Using the proven Fetkovich method, we aim to quantify the key parameters of the reservoir and assess its ability to produce hydrocarbons over time. The results of this study will serve as a basis for strategic decisions to optimize production and extend the economic life of the deposit. The Fetkovich method is widely recognized for its ability to characterize reservoirs and evaluate their performance. In this study, we are applying it to the Upper Pinda Reservoir, focusing on the Lukami-02 well. By analyzing the production data from this well, we are looking to determine the petrophysical parameters of the reservoir, estimate the reserves in place and predict future production trends. This approach will allow us to gain a better understanding of the tank's behavior and optimize production strategies.

Before deciding on the start of production of a hydrocarbon deposit, the operating company considers the following questions:

- Will this reservoir be efficient or economically profitable?
- What is the reserve in place?
- What techniques can be used to put it into operation? and
- How will his depression evolve over time?

In this work we will focus mainly on the first question and partially on the last question. There are several theories that were developed for the study of the performance of the reservoir, but for the choice of this work, we will use the Fetkovich method.

This study aims to assess the significant impact of the performance of the upper pinda reservoir on hydrocarbon production. In particular, it focuses on examining the reservoir performance within the radius of the Lukami 02 well in the Lukami field, located in the coastal basin of the Democratic Republic of Congo.

Assumptions

At the end of this work, we have set ourselves two hypotheses, namely:

- The determination of the productivity index would give an idea of the productivity of the upper pinda reservoir.
- Fetkovich correlation could be applied to study reservoir performance in the case of our work

General Objective

This work aims to analyze the performance of the upper pinda reservoir in the drainage radii of the Lukami-02 well.

Specific Objectives

- To better understand the Pinda Superior reservoir and its behaviour under exploitation.

• Optimize production from the Lukami-02 well and improve hydrocarbon recovery.

• Provide a solid basis for decision-making regarding future field development.

To achieve these objectives, both general and specific, we will:

• To resemble all the PVT data needed to carry out this work.

• Determine the productivity index.

• Apply the Fetkovich method to draw the IPR curve.

2. Materials and Methods

To carry out this work we proceeded in the following way. The methods of analysis that allowed us to make a synthesis on the theme of our work.

The documentary techniques that allowed us to consult similar works on our subject, the sources of which are;

• Books in the library.

• The collection of data from Pérenco-Rep.

• The Internet.

• Previous briefs and.

• Course grades.

During this work, we used the following software approaches:

• Word.

• Excel.

Presentation of the Study Area

Our study concerns the LUKAMI oil field, which is located in the northern part of the Congolese coastal basin. This field is located exactly 12 km from the Atlantic coast of the Democratic Republic of the Congo in the offshore area of the coastal basin with an average depth of between 30 and 40 feet. (Figure 1)

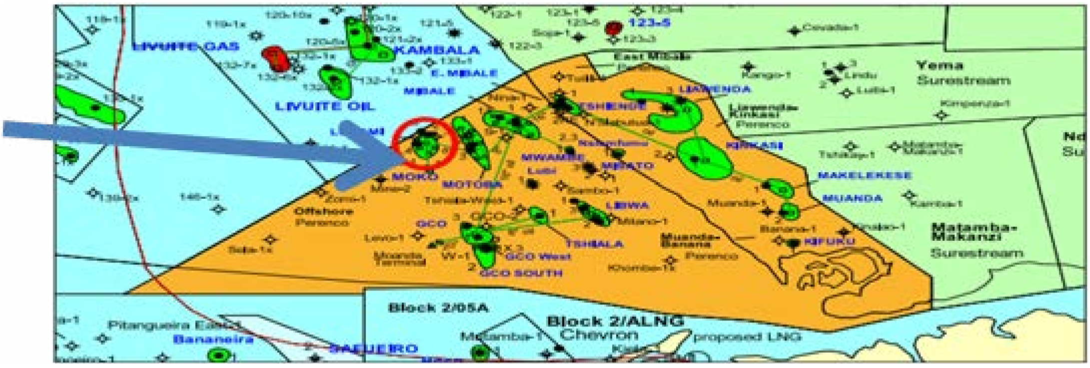

Figure 1: Lukami Field Location Map [1].

Geological Aspects of the Field

The Lukami oil field is a complex geological structure that is characterized by a series of faults and folds, which allow the existence of hydrocarbon reservoirs. These reservoirs are made of solid sandstone with a porosity of between 20 and 30%, and a permeability ranging from 100 to 1000 millidarcys [2-4]. The Lukami Pinda fault block lies between two main syn-sedimentary normal listric faults that flow into the surface of the Aptian Loeme salt detachment. These main faults follow the northwest-southeast regional trend. The northern end of the fault block is truncated by a transverse fault with a steeper southwest-northeast transverse inclination (Figure 1.2) that later moved down to the north [2].

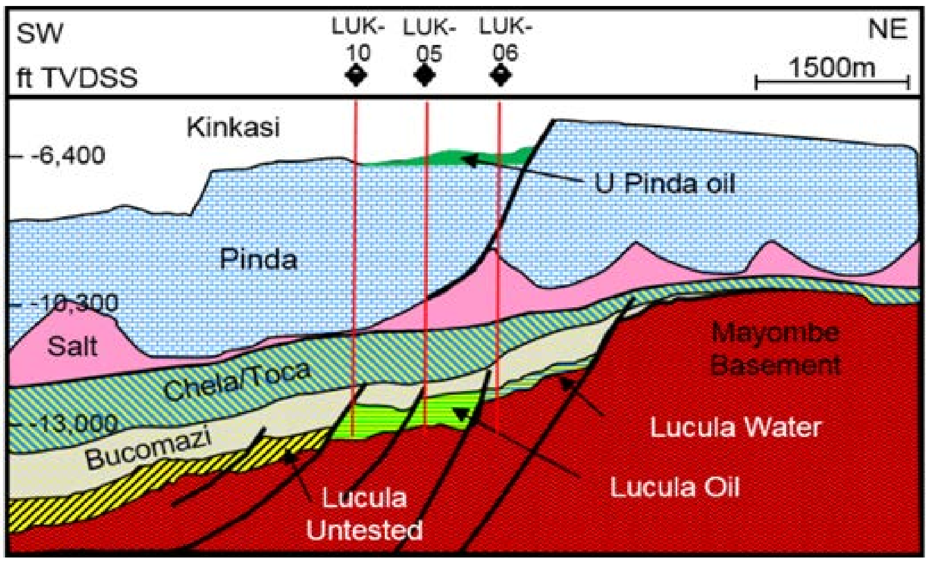

Figure 2: Schematic Section by the Lukami Field Accentuating the Two Discrete Oil Accumulations (Pinda Upper and Lucula), which are Separated Vertically by a Distance of about 7000ft [5].

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Field History

The discovery of the field under study was made in 1982, thanks to an exploitation drilling carried out by Chevron which confirmed the actual presence of hydrocarbons. After this discovery, 9 other wells were drilled in the same field. Table (1) gives us the chronology of the said drilling in the Lukami field.

Well	Years of drilling	Jacket	statut de Lucula de Pré-salifère	Superior Pinda Production	
				Putting it into production	Total production (MMstb)
Lukami-1X	1982	Lukami-1X	Not covered P	1990	0.53
Lukami-2X	1983	Lukami-2X	Producer 1984-1988	1990	0.52
Lukami-3	1984	None (P&A)	No Tanks Produced	N/A	
Lukami-4	1984	Lukami-1X	Producer 1984 to present	N/A	
Lukami-5	1984	Lukami-5	Producer 1985-present	N/A	
Lukami-6	1985	Lukami-5	Containing water	1989	0.04
Lukami-7	1985	Lukami-7	Producer 1986-1988	1989	1.04
Lukami-8	2000	Lukami-1X	No covered	2000	0.76
Lukami-9	2000	Moko-1X	No covered	2000	0.44
Lukami-10	2000	Lukami-5	No tanks producer	N/A	

Table 1: Timeline of Drilling in the Lukami Field [1].

Study of the Performance of the Upper Pinda Tank in the Drainage Radius of the Lukami-02 well in Applying the Fetkovich Method

This item deals with the comparative analysis of the performance of the pinda reservoir above the drainage radius of the Lukami 02 well.

In this part, using the Fetkovich method on the one hand and Perenco's PVT data from 2020 on the other hand, it is a question of drawing two IPR curves, one with the initial pressure and the other with the current pressure of the reservoir in order to evaluate the evolution of the productivity of the said reservoir over time.

Presentation of the PVT Data of the Lukami Well – 02 the Data in Table (2) will Allow us to Understand the Present Study.

01	Average Tank Temperature (Pe)	170	°F
02	Initial Tank Pressure (pi)	3670	Psi
03	Bubble pressure (pb)	1160	Psia
04	Current Tank Pressure (pr)	950	Psi
05	Reservoir thickness (h)	83,15789	Ft
06	Permeability (k)	5	Md
07	Reservoir porosity (Φ)	16	%
08	Oil viscosity (μo)	2.13	Cp
09	Volume formation factor (Bo)	1.2	Lbm/stb
10	GOR	217	Scf /stb
11	Drainage Radius (re)	1320	Ft
12	Tubing Diameter (rw)	4.2	(In)

Table 2: PVT Data from the LUK-02 Well [6].

Drainage Mechanism

The oil-producing wells are initially eruptive, since their production and this thanks to clean energy from the deposit. The primary recovery of oil and to a lesser extent of gas is essentially related to the reservoir drainage mechanisms. Most deposits contain several sources of energy, the relative importance of which varies with time [7-10]. The drainage mechanism refers to how petroleum fluids are expelled from the reservoir to the well. Understanding drainage mechanisms is essential to optimize oil recovery. In this regard, we agree with MOKRANI KARIMA and CHERGUI HAYAT to distinguish the six main components of the drainage mechanism, namely: expansion drainage, rock and pore water compressibility, a factor affecting drainage

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mechanisms, combinations of several drainage mechanisms, performance of drainage mechanisms and drainage index [7-12].

Analysis of PVT Data and Presentation of Results

Determination of Reservoir Performance

The reservoir's performance reflects the reservoir's ability to supply hydrocarbons to the well. This capacity therefore shows the productivity of the reservoir, which is characterized by its index, which is commonly called the productivity index. This analysis is determined in the laboratory by constructing the IPR curve by analytical or empirical formulas that govern the flow of oil to the well into which the characteristics of the reservoir are introduced.

Determination of the Initial Productivity Index

We notice in Table 2 above that the initial pressure of the tank is sadly higher than the bubble pressure, so we are facing an undersaturated tank. We know that when production is triggered, the first flow regime that appears is the transient regime. Let us develop the productivity index equations that correspond to each flow regime. In the case under consideration we will use equation (1) of which:

$$j^* = \frac{q}{(p_i - p_{wf})} = \frac{kh}{162.6\mu_o B_o\left[\log(t)+\log\left(\frac{k}{\emptyset\mu_o c_t r_w^2}\right)-3.33+0.87*S\right]}$$ [1] [12-14].

With:

k : reservoir permeability = 5 mD

h : rock thickness= 83,15789 ft

μ_o : oil viscosity = 2,13 cp

Bo : Volume Formation Factor =1,2 lb/stb

t: the duration of the plan = 2ans

s: skin factor = -2,8

Ø : reservoir porosity = 16%

c_t : total compressibility = 7,48.10-6 psi-1

rw: Well radius 4,2 inch = 0,35ft

$$j^* = \frac{5\times 83{,}15789}{162.6\times 2{,}13\times 1{,}2\left[\log(2)+\log\left(\frac{5}{16\times 2{,}13\times 7{,}48.10^{-6} r_w^2}\right)-3.33+0.87\times(-2{,}8)\right]} = 0{,}13354208$$

Determination of the current productivity index

After a few years of production, the pressure drops in the tank and the gases relax. This brings us into conduction such that the bubble pressure ends up above the tank pressure. So, the reservoir becomes two-phase.

Equation (2) corresponds to this type of tank, we have:

$$j^* = \frac{q}{(\bar{p}-p_{wf})} = \frac{kh}{141.2 B_o \mu_o\left[\ln\left(\frac{r_e}{r_w}\right)-\frac{3}{4}+s\right]}$$ [2]

Avec:

k : = reservoir permeability 5 mD

h : rock thickness = 83,15789 ft

μ_o : oil viscosity = 2,13 cp

Bo: Volume Formation Factor = 1,2 lb/stb

t: the duration of the plan = 2ans

s: skin factor = -2,8

r_w: well radius4,2 inch = 0,35ft

r_e : drainage radius = 1320ft

$$j = \frac{5\times 83{,}15789}{141.2\times 1{,}2\times 2{,}13\left[\ln\left(\frac{1320}{0{,}35}\right)-\frac{3}{4}+(-2{,}8)\right]} = 0{,}246381$$

Plotting the IPR curve itself

To draw the IPR curve, we will use the results of the productivity index scanned in the aforementioned point. Formula (3) will help us determine the initial and current pressure of the Lukami-02 well.

IPR Curve Plotting with Initial Pressure

We mentioned two models for plotting the IPR curve in the previous chapter, but for the purposes of this work we will use the Fetkovich model.

The general equation of tank performance developed by Fetkovich is as follows:

$$Q = j^*(\bar{p} - p_b) + \frac{j^* p_b}{1{,}8}\left[1 - 0.2\left(\frac{p_{wf}}{\bar{p}}\right) - 0.8\left(\frac{p_{wf}}{\bar{p}}\right)^2\right]$$ [3]

Starting from this equation we can make iterations to constitute the pairs of the points between the pressures of the reservoir and the pressure at the bottom of the well [12-14].

Qo	Pwf
421,251072	0
419,255616	100
416,236849	200
412,19477	300
407,129381	400
401,040681	500
393,92867	600
385,793348	700
376,634715	800
366,452771	900
355,247516	1000
343,01895	1100

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329,767073	1200
315,491885	1300
300,193386	1400
283,871576	1500
266,526456	1600
248,158024	1700
228,766281	1800
208,351228	1900
186,912863	2000
164,451187	2100
140,966201	2200
116,457904	2300
90,9262952	2400
64,3713758	2500
36,7931455	2600
8,19160422	2700
0	2800

Table 3: Summarizes the Results of the Parameters Calculated to Study the Performance of the Initial Reservoir.

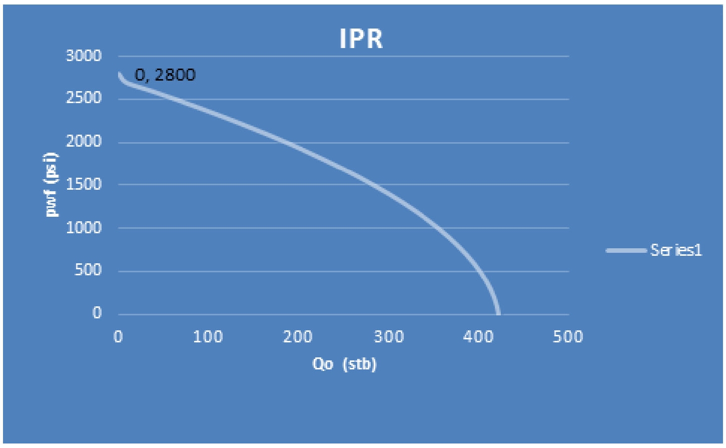

Figure 3: The Initial IPR Curve of the Lukami-02 well

Plotting the IPR Curve with the Current Pressure Using the Same Procedure, the IPR with the Average Tank Pressure of 950 psi gives us:

Qo	**Pwf**
107,038857	0
105,434076	50
103,357301	100
100,808533	150
97,7877693	200
94,2950118	250
90,3302601	300
85,8935141	350
80,9847739	400
75,6040394	450
69,7513107	500
63,4265877	550
56,6298705	600

49,361159	650
41,6204532	700
33,4077532	750
24,723059	800
15,5663705	850
5,9376877	900
0	950

Table 4: Summarizes the Results of the Parameters Calculated to Study the Performance of the Current Reservoir

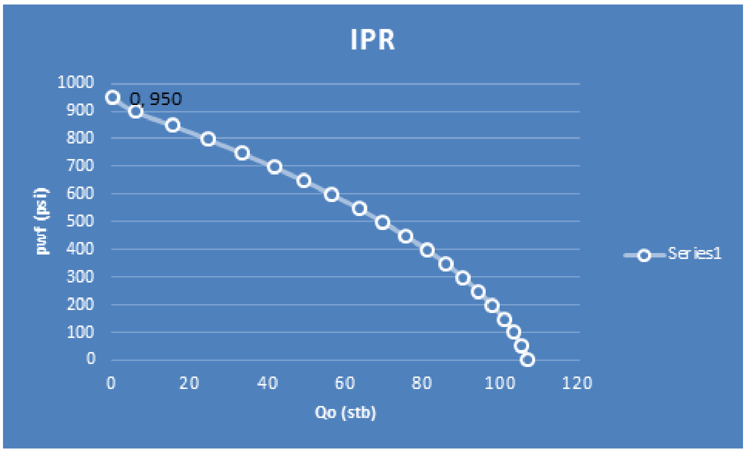

Figure 4: The Current Ipr Curve of the Lukami-02 Well

3. Interpretation of Results and Discussions

Based on the results presented above, we can say the following:

The IPR plotted using the initial pressure of the reservoir rock at the radius of influence of the Lukami-02 well gives us the capacity that the reservoir had before it was put into operation. And the IPR plotted considering the current pressure gives us the capacity of the reservoir to supply the oils in the Lukami-02 well. Looking at the two IPR curves we can clearly see that the reservoir had the capacity to produce a maximum flow of more than 400 stb at the beginning, but today it drops to a maximum flow of less than 150 stb. This is quite normal because the exploitation of an oil field leads to its depression, if the quantity produced is not replaced by an invasion of water. (Case of the reservoir without aquifer). However, we have understood that our reservoir is devoid of aquifers. So, we can clearly see that if we try to resemble the two curves, we will have a situation such that the initial IPR curve will be above the current IPR curve, because its average reservoir pressure gives a high maximum flow rate compared to its present production. If production continues, the depression will also continue, and the IPRs that will be plotted in the future will be below the one plotted today.

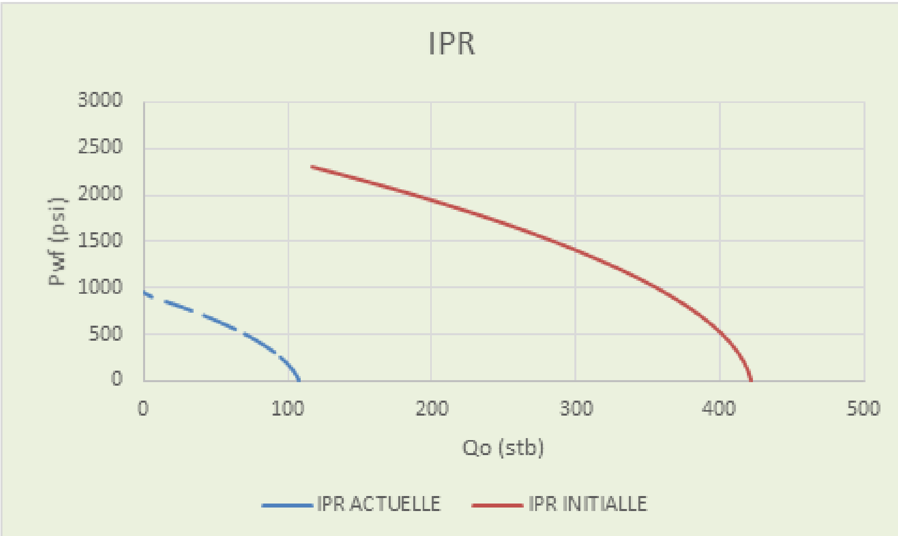

Figure 5: Combination of the Initial IPR and the Current IPR.

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This comparative analysis by tracing IPR curves, one with the initial pressure and the other with the reservoir pressure, will be evaluated in 2020 at the drainage radii of the LUKAMI-02 well.

Our studies have led to the following critical observations and results:

Regarding the observations, we noted that when hydrocarbons are extracted, the pressure decreases, which has an impact on the decrease in oil production in the well.

To this end, the pressure and quantity of oil reserves in place are falling. In terms of results, our analysis indicated that the current pressure of the upper pinda reservoir is lower than the initial pressure. This justifies a high rate of depression at this level. We have seen that in its initial state this well had a high production capacity with a maximum flow of more than 400 stb, but currently, it has fallen to less than 150 stb. Also, we noted that the reservoir at the drainage radii of the Lukami -02 well is devoid of aquifer. This state of affairs also explains the significant drop in the pressure in the tank.

4. Conclusion

This work concerning the contribution to the performance study of the upper pinda reservoir in the drainage radius of the Lukami - 02 well by applying the Fetkovich method, made it possible to identify our study area, namely the Lukami oil field in the coastal basin of the D.R.C. This field consists of massive sandstone reservoirs with high porosity and permeability. This well is drilled from offshore platforms located above the field, after extraction the hydrocarbons produced are transported to onshore processing facilities. It also allowed us to understand fundamental concepts related to the productivity of oil reservoirs. The study of the properties of physical hydrocarbons that are useful for the understanding and optimization of oil production, the petrophysical characterization of rocks whose porosity, permeability and saturation are essential to evaluate the productivity of the said reservoirs. The drainage mechanism relating to the oil extraction process has helped to understand how to maximize oil production. Regarding reservoir productivity, we have understood that the increase in oil production requires the planning of production strategies in the present and in the future.

Thus, based on the Fetkovich method and the PVT data from Perenco, critical observations were made as well as related results were found. Indeed, most of our results show that in its initial state this well had a high production capacity with a maximum flow rate of more than 400 stb, but currently, it has fallen to less than 150 stb. In relation to these results, we have been pleased to suggest the following in the form of a recommendation. The productivity of the Lukami oil field at the drainage radii of the Lukami - 02 well, requires the monitoring of its flow rates and pressure according to the parameters of the reservoir relating to the Fetkovich method. The aim is to adjust production strategies and optimize the exploitation of the reservoir in the area of influence of the Lukami - 02 well.

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