Practical Application of Reactivation Strategy as a Production Optimization in DAL-031 Shut-in Well of DAL Structure

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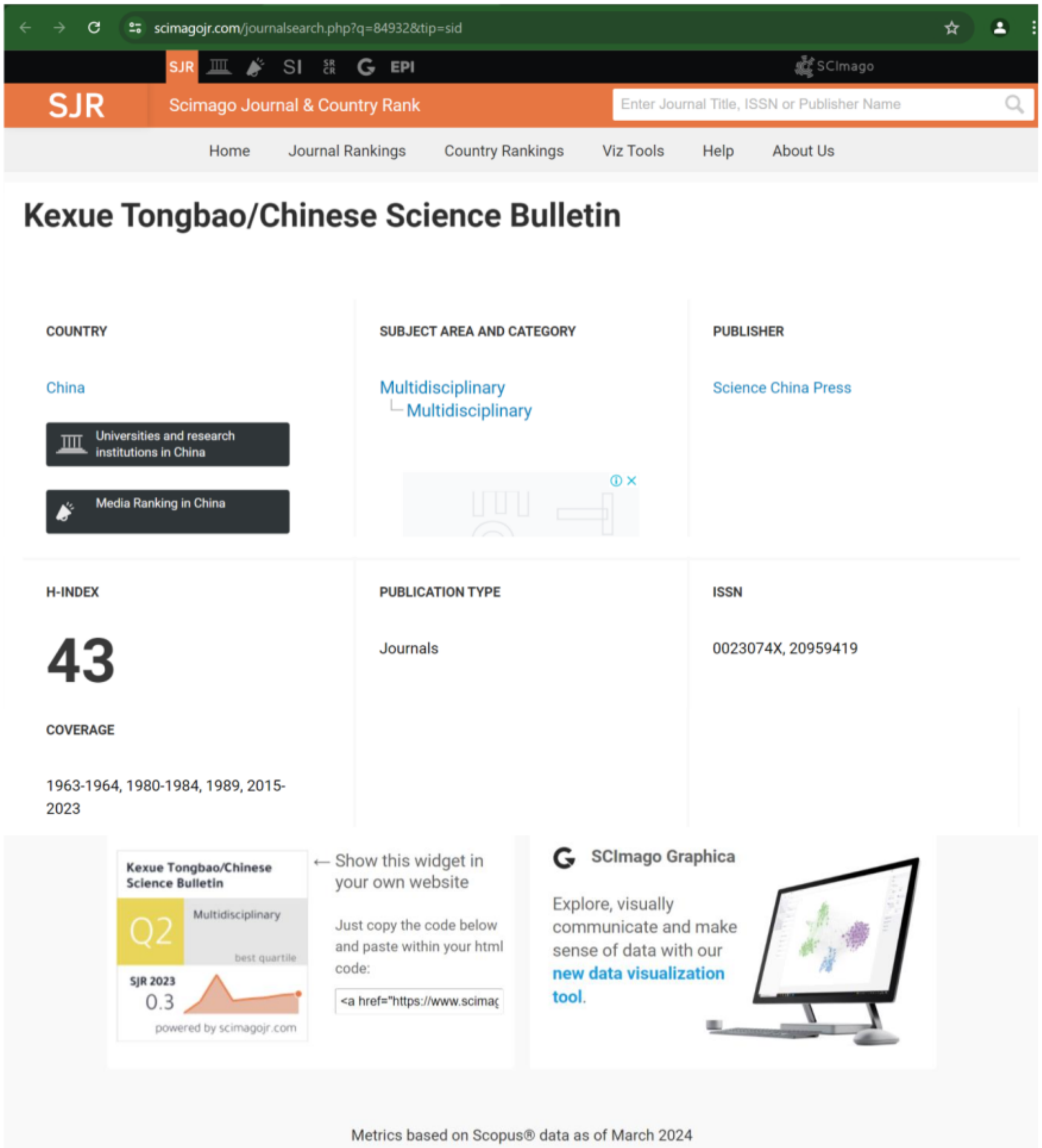

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Practical Application of Reactivation Strategy as a Production Optimization in DAL-031 Shut-in Well of DAL Structure

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ABSTRACT

Most of the shut-in wells in the DAL structure have a high water cut value. Strategy for reactivation of shut-in wells in the DAL structure begins with the screening of wells and layers with well parameters such as high water cut (WC) more than 90%, comparison of recovery factor from cumulative production with in-place wells radius and calculation of recovery factor based on special core analysis (SCAL) data, production forecast, and economic analysis. Based on the screening results, the DAL-031 well was selected as a candidate for the reactivation well, which was closed on January 21, 2016 due to high water cut. The strategy for reactivation of the DAL-031 well by perforating at interval 1884-1887 m and obtained oil gain of 47.04 bopd with correlation well analysis and forecast with exponential decline type for 8 years. Economic analysis was carried out by analyzed economic indicators 315.42 MUSD of net present value (NPV), 77% of internal rate of return (IRR), and 11 months and 28 days of pay out time (POT). Based on the technically and economic analysis, it was concluded that reactivation strategy of DAL-031 shut-in well is feasible to be applied.

1. INTRODUCTION

At the beginning of production, the amount of oil recovery is very high, but the longer a well is in production, the reservoir pressure will decrease, which can cause a decrease in oil production. Oil production will be decreased and replaced by increased water production. Increased water production will affect the high water cut value, which can indicate problems in wells conditions such as water coning and water channeling, so it is necessary to analyze and evaluate production. High water cut value are generally found in mature oil field that have been in production for a long time [1].

A mature field is an oil field where production conditions have decreased or reached a productive limit. According to SKK Migas in [1], mature oil fields have the characteristics of a recovery factor value greater than 30%, a water cut (WC) value higher than 90%, and have been in production for more than 30 years.

The LAZ field is a mature oil field in South Sumatera Province that started producing in 1947. During the time, water production at the LAZ field increases until the end of 2022, when the water cut value reach 94%. DAL structure is one of the structures in the LAZ field, that started production in 1949 with a 0% water cut and over time tends to increase until at the end of 2022, the water cut value was reaches 97% [2].

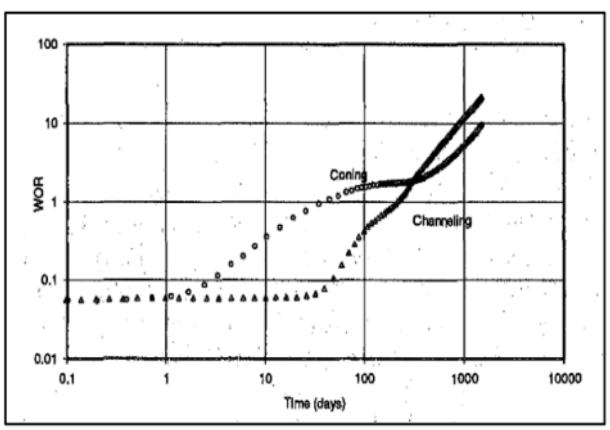
2. BASIC CONCEPTS AND CALCULATIONS

2.1 High water cut analysis

The primary cause of a decline in well productivity is excessive water production. The inflow and outflow curves are impacted by increasing the water cut, which also increases the cost of lifting the fluid to the surface and the expense of water treatment and disposal. Excessive water production can be caused by mechanical problems or other problems related to the reservoir, such as water channeling or water coning [1], [3].

Coning is defined as a production problem that causes water below the production zone to flow through the perforation zone around the borehole, reducing oil production. Coning can occur when the oil production rate exceeds the critical rate at which coning can occur, excessive pressure draw-down (exceeding the buoyancy force that causes the oil to separate from the water), and exorbitant vertical permeability. Coning causes high water cut problems due to water will enter and oil will be hindered by higher water mobility [1], [3].

According to [1], there are 7 (sevens) parameters that influence the occurrence of water coning, such as mobility ratio, thickness of the oil zone, comparison of the gravitational and viscous forces, distance between wells, comparison of vertical permeability with horizontal permeability, perforation interval, and well production rate. Channeling defined as the entry of formation water from a high-pressure zone into well through channel to oil production zone with lower pressure. These channels could be in the form of fractures (fracture channeling), exorbitant horizontal permeability due to rock heterogeneity known as multilayer channeling, and due to poor cement bond between casing and formation [1], [3]. By analyzing production history data, [1], [4- 6], was able to successfully identify the water coning and channeling phenomena. Chan used the WOR and WOR derivative (WOR') graphs to determine and assess the potential causes of coning and channeling as shown in Figure 1.



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Volume 69, Issue 06, July, 2024

Figure 1. Water coning and channeling WOR comparison [4]

[4], has also obtained additional graphs, collectively known as Chan's diagnostic plots, to examine bottom water coning, multi-layered channeling, rapid channeling, near-wellbore water channeling, and normal displacement. The equations used to calculate WOR and WOR' are as follows:

$$WOR = \frac{qw}{qo} \quad (1)$$

$$WOR' = \frac{WOR_{n+1} - WOR_n}{Day_{n+1} - Day_n} \quad (2)$$

2.2 Reserves estimation

Reserves are the number of hydrocarbons in a reservoir that can be produced commercially using existing technology. One of the methods used for estimating the amount of oil reserves based on production data after a certain time interval is the decline curve analysis (DCA) method. The main requirement for using the decline curve method is that the decline in production is caused by the state of the reservoir, not by a decline in the ability of production equipment [1], [3]. Reserves using the decline curve method is based on production data over a certain time interval. This method can only be used if an oil/gas field has been producing and has a declining profile of production [3].

Forecasting the amount of hydrocarbon reserves, specifically oil or gas, using the decline curve method entails estimating the extrapolated results obtained from a curve constructed by plotting the production data or cumulative production versus production time [1]. Production decline analysis is analysis of past trends in declining production performance for wells and reservoirs, such as rate versus time and rate versus cumulative production plots. Arps, 1945 in T. Ahmed [7] and [8- 12], recognized the following three types of rate-decline behavior:

1. Exponential decline, also known as constant percentage decline or geometric decline, is defined by a decrease in output per unit time that is proportional to the rate of output and forms a straight line.
2. Harmonic decline, by plotting the log production rate (qo) against time, hyperbolic decline shows an upward curvature line on semi-log paper.
3. Hyperbolic decline, shows a decrease in the rate of production per unit time in direct proportion to the rate of production.

The type of decline is determined before estimating the number of remaining reserves and the age of the reservoir, which is calculated up to the q limit. There are several methods for determining the type of decline, including the loss-ratio method, the trial error and X^2 Chi-square test methods, and the Fetkovich method [1], [3]. Trial error method and the X^2 Chi-square test are carried out by estimating the value of q based on assumptions for various values of b, then determining the smallest difference between the actual q and the previously calculated q forecast. The calculation procedure for the trial error method and the X^2 Chi-square test is as follows [1], [3], [11]:

1. Create a table with the following columns: number, time (t), q actual, q forecast, decline rate (Di) with various values b, and X^2 which is the difference between q actual and q forecast.
2. Assume b values ranging from 0 to 1 ($b = 0$ for exponential decline, $0 < b < 1$ for hyperbolic decline, and $b = 1$ for harmonic decline).
3. Calculating Di for various types of decline.
   - Exponential decline ($b = 0$)

$$Di = \frac{\ln\left(\frac{qi}{qt}\right)}{t_t} \quad (3)$$

- Hyperbolic decline (0 < b < 1)

$$Di = \frac{\left(\frac{qi}{qt}\right)^{\boldsymbol{b}} - 1}{b\, t_t} \quad (4)$$

- Harmonic decline (b = 1)

$$Di = \frac{\left(\frac{qi}{qt}\right) - 1}{t_t} \quad (5)$$

4. Calculating the q forecast.
   - Exponential decline (b = 0)

$$qn = qi.\ e^{-Di.t} \quad (6)$$

   - Hyperbolic decline (0 < b < 1)

$$qn = qi\ (1 + b\ Di.t)^{-1/b} \quad (7)$$

   - Harmonic decline (b = 1)

$$qn = qi\ (1 + Di.t)^{-1} \quad (8)$$

5. Using the chi square test equation, calculate X^2 as the difference between q actual and q forecast.

$$X^2 n = \left|\frac{(fi - Fi)^2}{Fi}\right| \quad (9)$$

6. To calculate the next data, repeat the calculation procedure from step 3 to step 5.
7. Determine the smallest value of X^2 that shows the most appropriate curve for each type of decline.

The b value and the type of decline will be used in making production forecasts to estimate the well's production capacity in the future. Estimated ultimate recovery (EUR) is the total (cumulative) amount of oil that will be produced up to its economic limit (abandonment). It can be said that the estimated ultimate recovery is the accumulation of the cumulative oil production that has been obtained (Npt) and the cumulative oil production that will come up to its economic limit (Npt→limit) [1], [10], [11].

$$EUR = Npt + Npt{\rightarrow}limit \quad (10)$$

Furthermore, estimate remaining reserve (ERR) is an estimate of the number of reserves that can be retrieved that are still left in the reservoir or have not been produced.

$$ERR = EUR - Npt \quad (11)$$

2.3 Recovery factor

Recovery factor (RF) is defined as an amount that shows a ratio between producible hydrocarbon versus original hydrocarbon in place [1], [3]. The amount of recovery factor could be calculated using the J. J. Arps method, which is based on the current drive mechanism in the reservoir; special core analysis (SCAL) results based on the correlation between relative permeability versus water saturation, and fractional flow curve versus water saturation [1], [3]. The equation to calculate recovery factor based on SCAL is as

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Volume 69, Issue 06, July, 2024

follows:

$$RF_{(SCAL)} = (1\text{-}Swi\text{-}Sor) / (1\text{-}Swi) \times 100\% \quad (12)$$

2.4 Economic and sensitivity analysis

Oil and gas production is becoming increasingly important. There are several key characteristics of the oil and gas industry, including high risk and uncertainty, very large investment and capital costs (high cost), and very large profits (high profit) if properly realized. As a result, in the oil and gas industry, analyzing the economics of a project to determine feasibility and company management decision making is inseparable. An economic analysis using standard parameters of economic assessment in the petroleum industry, such as, net present value (NPV), internal rate of return (IRR) or rate of re-turn (ROR), pay out time (POT), profit to investment ratio (PIR), and discounted profit to investment ratio (DPIR), are required to determine whether a field has economic value or not [12- 14].

According to [15], after obtaining the results of economic indicators, a sensitivity analysis of economic values is carried out to anticipate changes in the parameters that are the economic indicators above. In addition, sensitivity analysis is also an analysis carried out to observe the effect of changes in parameters that will affect profit, seen from the results of economic indicators. The parameters used to carry out the sensitivity analysis are cumulative oil production, oil prices, total investment, and lifting costs [16].

3. RESEARCH METHODOLOGY

Strategies for reactivation of shut-in wells on the DAL structure begin with scatter plots for shut-in wells in the DAL structure for each layer, where oil rate (Qo), cumulative production (Np), and water cut (WC) were analyzed. The results of screening cumulative production (Np) with water cut (WC) obtained four priority quadrants, where the candidate wells for reactivation are in quadrant I, which is then screened for the availability of lumping data and analysis of recovery factors. The scatter plot for the DAL structure can be seen in Figure 2, as preliminary of the screening steps for deter-mining well candidates.

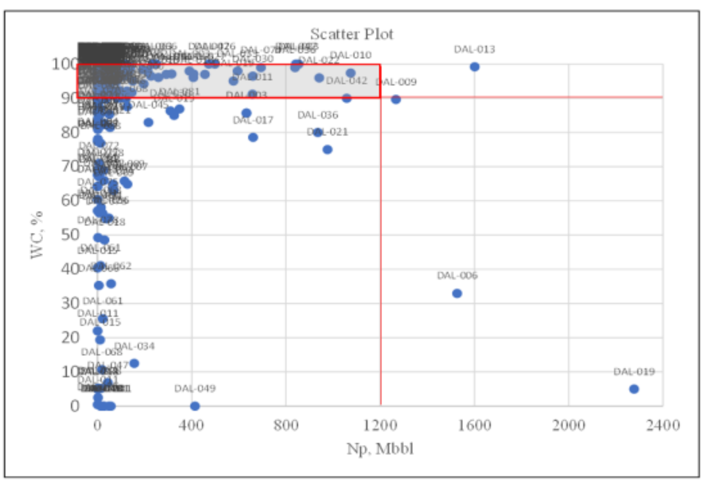

Figure 2. Scatter plot analysis of DAL structure

After screening using a scatter plot on shut in wells in the DAL structure, an analysis is then per-formed on the availability of lumping data in these wells which will then be used in the calculation of original oil in place (OOIP). From the lumping data, the net pay value (reservoir thickness) is obtained which is obtained from the gross rock volume (GRV) multiplied by net to gross (NTG) to determine the thickness of the reservoir which actually contains hydrocarbons and has been cut-off porosity, Vshale, and water saturation. In addition to net pay, water saturation data (Sw) and porosity data are obtained. The well data which has lumping data is calculated using the OOIP volumetric method.

The next step is calculating the recovery factor (RF) of the well by making a comparison between the cumulative production (Np) and the in-place radius of the well (OOIP). The recovery factor results of the wells will be compared with the recovery factor results obtained from the calculation of the SCAL data. Calculation of recovery factor from special core analysis (SCAL) data begins with collecting core sample data by knowing the values of water saturation, water permeability, and oil permeability, water and oil viscosity data are also needed to be used in fractional flow calculations [17].

The fractional flow curve describes the relationship of the total water flow rate to the water saturation value [16]. The optimal condition for optimizing production is that the recovery factor value of the well has a smaller value compared to the recovery factor value from the SCAL calculation data [1]. Selection and screening of wells with RF value by well < RF SCAL was carried out. The fractional flow curve based on SCAL data and the calculation of the SCAL recovery factor can be seen in Figure 3. From fractional flow graph of Figure 3, it is obtained the RF SCAL value of 54.41%.

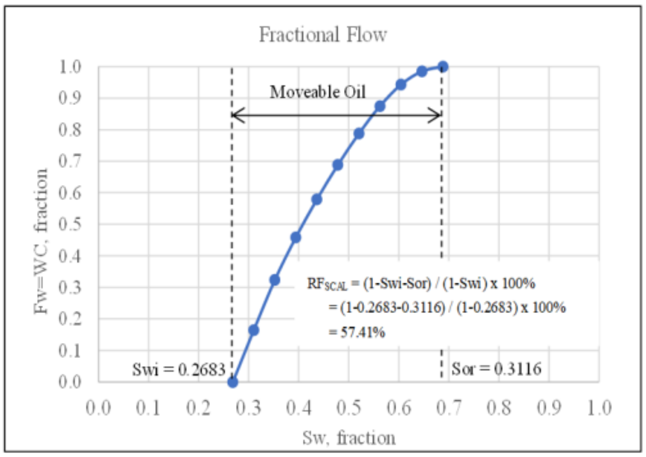

Figure 3. Fractional flow of DAL structure from SCAL

Based on the screening all shut-in wells in DAL structure, it is known that the L2 layer still has the potential for shut-in wells to be optimized with the screening parameters above. The L2 layer is a potential layer for production optimization, where there are many shut-in wells that can still be optimized for production. Based on well production data, there are several wells that are actively producing to date in the L2 layer, including the DAL-006 well and DAL-092 well.

4. RESULTS AND DISCUSSION

4.1 Analysis of DAL-031 as well candidate for reactivation

According to screening analysis of the DAL structure of the LAZ field, a candidate well for reactivation planning, the DAL-031 well in the L2 layer, was identified. The planning strategy for the reactivation of the DAL-031 well is also based on the correlation with the DAL-092 well as an actively producing well in the

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Volume 69, Issue 06, July, 2024

L2 Layer. The DAL-031 well is a shut-in well due to high water cut in the DAL structure which perforated the L2 layer on October 1, 2013 at interval 1892-1896 m and started production on October 3, 2013 and last produced on January 21 2016.

Table 1. Production data of DAL-092 as reference well

Well	Layer	Interval (m)	Date	Gross (Blpd)	Oil (Bopd)	Gas (MMscfd)	Water (Bwpd)	WC (%)
DAL-092	L2	1894.5 - 1896	6-Mar-23	826.6	50.8	0.387	775.8	93.85

4.1.1 High water cut analysis

DAL-031 well is a candidate well for reactivation with a high water cut value of 92% in the L2 layer. An analysis of the causes of the high water cut problem was carried out by conducting WOR and WOR derivative analysis and plotting the log-log plots for the cumulative production time so that the shape of the curve was obtained, which could then be analyzed with Chan's diagnostic plot to find out whether the behavior of water in the DAL-031 well with a high water cut value causes water coning or water channeling problems.

Figure 4 shows the log-log plot graph between WOR and cumulative production time shows that the initial WOR graph is constant, then the WOR increases, and the WOR trendline is drawn, which shows linear, the WOR' curve has increased as well as the WOR' trendline that follows from the WOR chart. This indicates a water channeling problem at the DAL-031 well, which resulted in an increase in the water cut value using Chan's diagnostic plot analysis [2], [4].

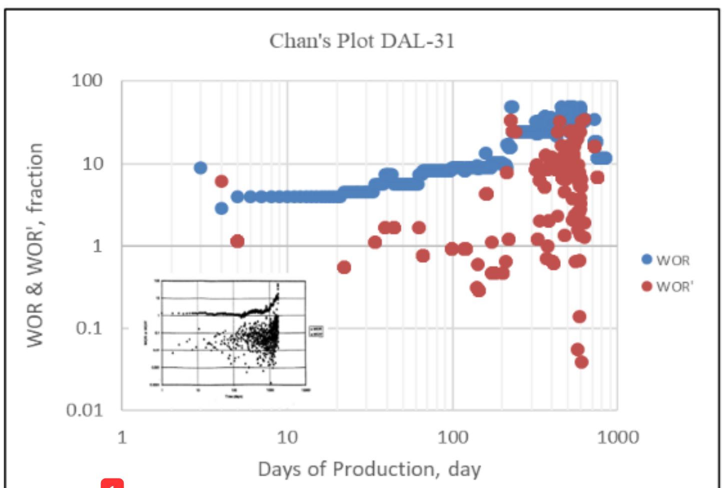

Figure 4. Chan's diagnostic plot of DAL-031 well

4.1.2 Original oil in place (OOIP) and recovery factor analysis

Based on the screening parameters of candidate wells for reactivation where OOIP and RF calculations were carried out as explained in the methodology section, the table below shows the results of OOIP and recovery factor (RF) calculations for the DAL-031 well as a reactivation candidate well. OOIP calculations use lumping data and are calculated using the volumetric method.

Table 2. OOIP calculation of DAL-031 well

Well	Layer	Net Pay	Por	Sw	Bo	Radius	OOIP
		m	fraction	fraction	bbl/stb	m	Mstb
DAL-031	L2	6.8	0.161	0.29	1.6	250	599.99

According to Table 2, the OOIP obtained at the DAL-031 well using the volumetric OOIP equation is 599.99 Mstb. This OOIP calculation will then be used to compute the recovery factor (RF) value, which is shown in Table 3 below, by dividing it by the cumulative production (Np). The recovery factor value of the well from the DAL-031 well is 20.82%, which indicates that the RF value of the well is smaller than the RF SCAL (20.82% < 57.41%), and this condition is optimal for optimizing production [1].

Table 3. Recovery factor by well calculation of DAL-031 well

Well	Layer	Np	OOIP	RF by Well
		Mstb	Mstb	
DAL-031	L2	124.9	599.99	20.82%

4.2 Reactivation strategy of DAL-031 well

Based on the correlation data of the L2 layer well to the DAL-092 well and RF screening data, the DAL-031 well was obtained as a candidate for reactivation with a perforation interval of 1884-1887 m by doing a squeeze at the existing perforation interval at a depth of 1892-1896 m then opening the perforation new L2 layer on interval perforation 1884-1887 m.

By planning the reactivation of the DAL-031 well, the DAL-092 well is used as a reference in analyzing the production flow rate that can be generated. March 6, 2023 is used as the analysis cut-off date. With the actual reference production rate data from the DAL-092 well 826.6 blpd and the assumption that the water cut value in the DAL-031 well is 94.31% with deeper perforations, then the oil rate of the DAL-031 well is obtained if reactivation is carried out at 47.04 bopd.

To analyze the production capability of the DAL-031 well if reactivation is carried out, a decline analysis is carried out then followed by a forecast. The first step taken is to determine the decline trend that represents the decline in L2 layer. The decline trend was taken from December 1, 2010 to March 1, 2013 where this trend represents a graph of the decline in other trends. The results of the decline line draw to a point where it indicates that the DAL layer of the L2 layer was mature, as shows in Figure 5. After the decline trend is determined, hence decline analysis can then be carried out at L2 layer using the trial-error and X2 Chi-square test methods to determine the type of decline whether it is exponential decline, hyperbolic decline, or harmonic decline [1], [5], [11].

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Volume 69, Issue 06, July, 2024

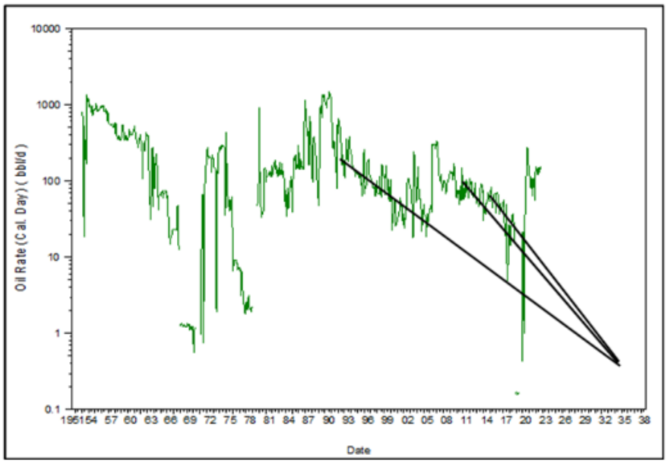

Figure 5. Decline trend of L2 layer

Based on the X2 Chi-square test method that shown in Table 4, it is assumed that the b value is from 0 to 1 and the Di and Qo forecast values are calculated, then X2 is calculated for each b value and the smallest total X2 value is selected as the nominal value of decline, namely 113.34 and the decline rate, Di= 0.0158 for each month (monthly decline) at the value of the exponential decline, b=0 which illustrates that the type of decline at L2 layer is exponential decline. Furthermore, determining the Qlimit is taken by averaging the last production rate of the wells in the L2 layer, then plotting between the wells and Qo and obtaining 9.41 bopd is then rounded up to 10 bopd. After determining the Q limit, the next step is to perform a forecast to find out the production lifetime of the DAL-031 well with Qoi 47.04 bopd and Npt 124900 bbl. In Figure 6, shows the production forecast of DAL-031 well using the exponential decline equation as decline type.

Table 4. Decline type calculation using trial-error and X^2 chi-square test methods

		Actual	b	0	b	0.1	b	0.2	b	0.3	b	0.4	b	0.5	b	0.6	b	0.7	b	0.8	b	0.9	b	1
t	Date	Qo	Di	0.0158	Di	0.0162	Di	0.0165	Di	0.0169	Di	0.0173	Di	0.0177	Di	0.0181	Di	0.0185	Di	0.01899	Di	0.0194	Di	0.0199
			Qo	X^2	Qo	X^2	Qo	X^2	Qo	X^2	Qo	X^2	Qo	X^2	Qo	X^2	Qo	X^2	Qo	X^2	Qo	X^2	Qo	X^2
1	1-Dec-10	95	93.51	0.02	93.48	0.02	93.44	0.03	93.41	0.03	93.38	0.03	93.34	0.03	93.3	0.03	93.27	0.03	93.23	0.03	93.19	0.04	93.15	0.04
2	1-Jan-11	56	92.04	14.11	91.98	14.07	91.92	14.04	91.85	14	91.79	13.95	91.72	13.91	91.65	13.87	91.58	13.83	91.51	13.78	91.44	13.73	91.36	13.69
3	1-Feb-11	62	90.6	9.03	90.51	8.98	90.42	8.93	90.33	8.89	90.24	8.84	90.15	8.79	90.05	8.74	89.95	8.69	89.85	8.63	89.75	8.58	89.65	8.53
4	1-Mar-11	80	89.17	0.94	89.07	0.92	88.96	0.9	88.84	0.88	88.73	0.86	88.61	0.84	88.49	0.81	88.37	0.79	88.25	0.77	88.12	0.75	87.99	0.73
5	1-Apr-11	60	87.77	8.79	87.65	8.72	87.52	8.65	87.39	8.58	87.25	8.51	87.11	8.44	86.98	8.37	86.84	8.29	86.69	8.22	86.55	8.14	86.4	8.07
6	1-May-11	98	86.4	1.56	86.25	1.6	86.11	1.64	85.96	1.69	85.81	1.73	85.66	1.78	85.5	1.83	85.35	1.88	85.19	1.93	85.03	1.98	84.86	2.03
7	1-Jun-11	65	85.04	4.72	84.88	4.66	84.72	4.59	84.56	4.53	84.4	4.46	84.23	4.39	84.07	4.32	83.9	4.26	83.73	4.19	83.56	4.12	83.38	4.05
8	1-Jul-11	102	83.71	4	83.54	4.08	83.37	4.16	83.19	4.25	83.02	4.34	82.85	4.43	82.67	4.52	82.49	4.61	82.31	4.71	82.13	4.81	81.95	4.91
9	1-Aug-11	96	82.39	2.25	82.21	2.31	82.04	2.38	81.86	2.44	81.68	2.51	81.49	2.58	81.31	2.65	81.12	2.73	80.94	2.8	80.75	2.88	80.57	2.96
10	1-Sep-11	84	81.1	0.1	80.92	0.12	80.73	0.13	80.55	0.15	80.36	0.16	80.17	0.18	79.98	0.2	79.8	0.22	79.61	0.24	79.42	0.26	79.23	0.29
11	1-Oct-11	75	79.83	0.29	79.64	0.27	79.45	0.25	79.26	0.23	79.07	0.21	78.88	0.19	78.69	0.17	78.5	0.16	78.31	0.14	78.12	0.12	77.93	0.11
12	1-Nov-11	59	78.57	4.88	78.38	4.79	78.19	4.71	78	4.63	77.82	4.55	77.63	4.47	77.44	4.39	77.25	4.31	77.06	4.23	76.87	4.15	76.68	4.08
13	1-Dec-11	84	77.34	0.57	77.15	0.61	76.96	0.64	76.77	0.68	76.59	0.72	76.4	0.76	76.21	0.8	76.02	0.84	75.84	0.88	75.65	0.92	75.47	0.96
14	1-Jan-12	109	76.12	14.2	75.94	14.39	75.75	14.59	75.57	14.79	75.38	14.99	75.2	15.19	75.02	15.4	74.83	15.6	74.65	15.8	74.47	16.01	74.29	16.21
15	1-Feb-12	89	74.93	2.64	74.75	2.72	74.57	2.79	74.39	2.87	74.21	2.95	74.03	3.03	73.85	3.11	73.67	3.19	73.5	3.27	73.33	3.35	73.16	3.43
16	1-Mar-12	95	73.75	6.12	73.58	6.24	73.4	6.36	73.23	6.47	73.06	6.59	72.88	6.71	72.71	6.83	72.55	6.95	72.38	7.07	72.21	7.19	72.05	7.31
17	1-Apr-12	98	72.6	8.89	72.43	9.03	72.26	9.17	72.09	9.31	71.93	9.45	71.77	9.59	71.61	9.73	71.45	9.87	71.29	10.01	71.13	10.15	70.98	10.29
18	1-May-12	98	71.46	9.86	71.3	10	71.14	10.14	70.98	10.28	70.83	10.43	70.67	10.57	70.52	10.71	70.37	10.84	70.23	10.98	70.08	11.12	69.94	11.26
19	1-Jun-12	64	70.33	0.57	70.19	0.55	70.04	0.52	69.89	0.5	69.75	0.47	69.61	0.45	69.47	0.43	69.33	0.41	69.19	0.39	69.06	0.37	68.93	0.35
20	1-Jul-12	60	69.23	1.23	69.09	1.2	68.96	1.16	68.82	1.13	68.69	1.1	68.56	1.07	68.44	1.04	68.31	1.01	68.19	0.98	68.07	0.96	67.95	0.93
21	1-Aug-12	67	68.14	0.02	68.02	0.02	67.9	0.01	67.78	0.01	67.66	0.01	67.54	0	67.43	0	67.32	0	67.21	0	67.1	0	66.99	0
22	1-Sep-12	79	67.07	2.12	66.96	2.16	66.86	2.21	66.75	2.25	66.65	2.29	66.55	2.33	66.45	2.37	66.35	2.41	66.25	2.45	66.16	2.49	66.07	2.53
23	1-Oct-12	61	66.02	0.38	65.93	0.37	65.84	0.36	65.75	0.34	65.66	0.33	65.57	0.32	65.49	0.31	65.4	0.3	65.32	0.29	65.24	0.28	65.16	0.27
24	1-Nov-12	93	64.99	12.08	64.91	12.16	64.83	12.24	64.76	12.32	64.69	12.39	64.62	12.47	64.55	12.54	64.48	12.61	64.41	12.69	64.35	12.76	64.29	12.82
25	1-Dec-12	49	63.97	3.5	63.91	3.48	63.85	3.45	63.79	3.43	63.74	3.41	63.68	3.39	63.63	3.36	63.58	3.34	63.53	3.32	63.48	3.3	63.43	3.28
26	1-Jan-13	61	62.96	0.06	62.92	0.06	62.88	0.06	62.84	0.05	62.81	0.05	62.77	0.05	62.73	0.05	62.7	0.05	62.67	0.04	62.63	0.04	62.6	0.04
27	1-Feb-13	57	61.97	0.4	61.95	0.4	61.93	0.39	61.91	0.39	61.89	0.39	61.88	0.38	61.86	0.38	61.84	0.38	61.82	0.38	61.81	0.37	61.79	0.37
28	1-Mar-13	61	61	0	61	0	61	0	61	0	61	0	61	0	61	0	61	0	61	0	61	0	61	0
			ΣX^2	**113.34**	ΣX^2	**113.92**	ΣX^2	**114.51**	ΣX^2	**115.11**	ΣX^2	**115.72**	ΣX^2	**116.34**	ΣX^2	**116.96**	ΣX^2	**117.59**	ΣX^2	**118.23**	ΣX^2	**118.88**	ΣX^2	**119.53**

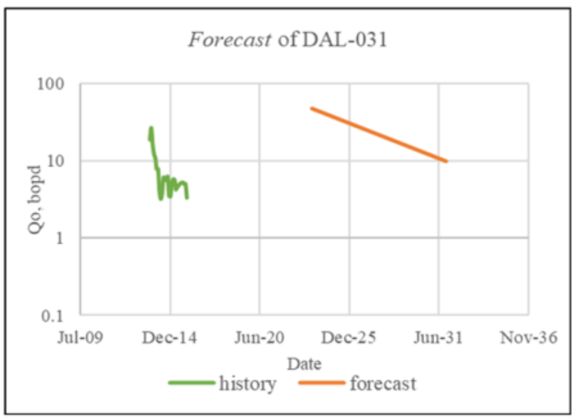

Figure 6. Production forecast of DAL-031 well

Calculations are made until Qt reaches the t limit of 10 bopd, that is, until the 98th month. In the 98th month which is the end of the forecast for the DAL-031 well until it reaches the t limit of 10 bopd, the Npt-limit = 70273 bbl is obtained. It obtained 195.173 Mbbl of estimated ultimate recovery (EUR), 32.53% of recovery factor (RF), and 70.273 Mbbl of remaining reserves (RR).

4.4 Economic and sensitivity analysis

The final step in planning the reactivation of the DAL-031 well is to carry out an economic analysis to find out whether the work or project has economic value and is feasible to develop. The DAL-031 well reactivation plan uses the PSC Cost Recovery contract model with an oil price of 61 USD/bbl. Economic analysis on the DAL-031 well based on five economic indicators is shown in Table 5. Obtained values 315.422 MUSD of net present value (NPV), 77% of internal rate of return (IRR), 11 months and 28 days of

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pay out time (POT), 0.885 of profit to investment ratio (PIR), and 0.517 of discounted profit to investment ratio (DPIR) as shows in Table 6.

Table 5. Data of economic calculation

Data	Value	Unit
Project Lifetime	8	years
Investment	610	MUSD
Oil Price	61	USD/STB
Discount Rate	11%	per year
FTP	20	%
OPEX	12	USD/STB

Table 6. Economic calculation results for DAL-031 well

Parameters	Value	Unit
NPV	315.422	MUSD
IRR	77	%
POT	0.991	year
PIR	0.885	
DPIR	0.517	

After analyzing the five economic indicators, a sensitivity analysis of four parameters was carried out, such as cumulative oil production, oil prices, total investment, and lifting costs [16]. Sensitivity analysis on the reactivation plan of the DAL-031 well was carried out to anticipate changes in the parameters that become economic indicators. In this sensitivity analysis, it is done by changing the sensitivity of the four parameters above with an increase and decrease of 10% and 20%, hence a spider diagram plots for the economic indicators is shows in Figure 7 and Figure 8, respectively.

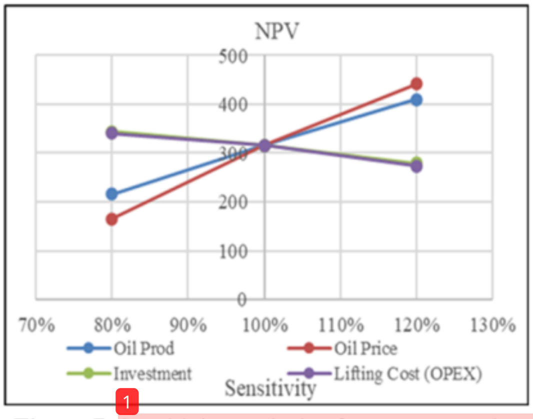

Figure 7. Sensitivity analysis of net present value (NPV) DAL-031 well

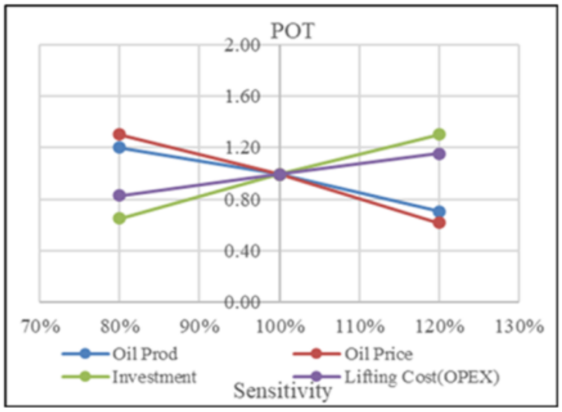

Figure 8. Sensitivity analysis of pay out time (POT) DAL-031 well

5. CONCLUSIONS

From the result and discussion above, it concludes that:

1. From the results of screening of the wells and layers in the DAL Structure of the LAZ Field, it was obtained that DAL-031 is a candidate well for reactivation planning based on parameters, such as shut-in well, has a high water cut value (92%), has lumping data, and recovery factor of DAL-031 value less than recovery factor of SCAL (20.82% < 57.41%).

2. Strategy of DAL-031 well reactivation plan, an oil gai n analysis of 47.04 bopd by perforating at interval 1884-1887 m was obtained by conducting a decline analysis with the exponential decline type using the trial error and X2 Chi-square test and forecast methods with a production lifetime of 8 years up to a Qlimit of 10 bopd.
3. Based on the economic analysis by observing the economic indicators; 315.42 MUSD of net present value (NPV), 77% of internal rate of return (IRR), and 11 months and 28 days of pay out time (POT), 0.885 of profit to investment ratio (PIR), and 0.517 of discounted profit to investment ratio (DPIR).
4. The reactivation strategy of DAL-031 well is based on technically and economically able to improve the production and can be implemented in the field.
5. Before reactivation of the well implemented, it is necessary to pay attention to the integrity of the well where it is hoped that the well will have good integrity, such as having good cement bonding and no damage to the casing to reduce the risk of problems occurring which can be detrimental from the start of the well-being planned until the well is permanently abandonment.

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Practical Application of Reactivation Strategy as a Production Optimization in DAL-031 Shut-in Well of DAL Structure

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