PERFORMANCE ANALYSIS OF OIL AND WATER PRODUCTION IN FIELD X USING DIAGNOSTIC PLOT

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ABSTRACT
Production wells have to be evaluated periodically, one of the problems that can occur is early water problems. Using X-Plot, Chan’s Diagnostic Plot, Decline Curve Analysis and Hall Plot analysis be able to detect RN-01 and RN-02 wells experienced multilayer channeling and RN-03 experienced normal displacement with high WOR.

Keywords: Water Chaneling, X-Plot, Chan’s Plot, Hall Plot, Decline Curve Analysis

INTRODUCTION
Wells that produce oil are declared to have economic value if they are able to produce large amounts of oil and get profits. However, it is unavoidable that a problem is often found during the production process, one of these problems is the production of premature or excess water from the reservoir which can significantly affect the oil production process. Some of the most common early water production problems are caused by water coning and water channeling. Early water production can cause cost implications for surface facilities, artificial lift systems, corrosion and scale problems, decreased recovery factor and reduced reservoir performance.

The method used in this paper is based on the X plot method, Chan’s Diagnostic Plot and Decline Curve Analysis to determine the performance of the production well before the well is diverted into an injection well. The Hall Plot method is used to evaluate the performance of injection wells.

METHODOLOGY
X-plot method is a waterflood analysis method derived from buckley-leverett’s 1-D equation (Ershaghi and Omorogie, 1978) based on the semi-log relationship between the ratio of oil/water relative permeability to water saturation. The X-plot method is a linear relationship between cumulative oil (Qo) and variable water-cut features. In this plot only used water cut >50%. Changes in the slope of the three wells indicate that the wells have layers with varying permeability (Echufu, 2010).

Limitations on application in the field include: period waterflood after breakthrough, poor mobility ratio in field conditions and operating processes such as infill drilling and the addition of perforation intervals that can affect parameters m and n. These limits are used to minimize errors in results.

For X-Plot, the calculation of the value X is used using the formula:

\[ X = \ln \left( \frac{1}{f_w} - 1 \right) - \frac{1}{f_w} \] ...............(2.1)

Where:

\[ f_w = \frac{\text{Water Rate}}{\text{Total liquid rate}} = \frac{q_w}{(q_o + q_w)} \] ............(2.2)

Chan Diagnostic Plot is a method used to determine the mechanism of excessive water and gas production in wells that produce oil (oil well only). Chan Diagnostic plot uses the plot between WOR versus time and logs of plot between WOR derivative versus time to determine the problem of water behavior in the production well. There are 3 mechanisms of excessive production of water in production wells: coning, channeling and high permeability layer breakthrough. (Chan, 1995).

\[ WOR = \frac{\text{Water rate}, q_w}{\text{Oil rate}, q_o} \] ...............(2.3)

\[ WOR_n = \frac{(WOR_{n+1} - WOR_{n-1})}{(t_{n+1} - t_{n-1})} \] ...............(2.4)
remaining oil or gas reserves of a reservoir that has decreased production and has not changed its production method. Decline Curve itself is divided into 3 types of trendline decline based on exponent decline value (b):

• Exponential Decline (b=0)
• Hyperbolic Decline (0<b<1)
• Harmonic Decline (b=1)

The X2 chisquare test trial error method estimates value of the exponential decline rate (Di), and the estimated rate of future oil production (Qo Forecast). From the results of this test will be produced the most aligned curve for the analysis of the decline curve, which is a curve that has the smallest value of X2 after which the remaining amount of oil reserves, ultimate recovery and the age of the well.

The Hall plot method is a method used to analyze the injection performance in the injection well and analyze the problems that occur in the well and conclude whether the injection well is efficient or not. Hall's analysis of the plot was done by plotting the injection pressure versus the cumulative injected water. This method uses the assumption of steady-stated injection rate.

RESULT AND DISCUSSION

By using field X production data owned by PT. Pertamina EP, an evaluation is carried out using the methods that have been studied.

WELL RN-01

RN-01 well showed production began in July 2004 with an oil production rate of 867 bbl/day, water production rate of 557 bbl/day and water cut by 28%. production at RN-01 wells lasted until February 2015 with oil production flow rate of 0 bbl/d, water flow rate of 1360 bbl/day and water cut 100%. In September 2008 there was a drastic decline in oil production and in June 2011 oil production was very low while water production was high which indicates a problem.

Using Chan's Water Diagnostic Plot, shows that well RN-01 has multilayer channeling as shown below:

![Chan's Diagnostic Plot RN-01](image)

**Figure 2. Chan’s Diagnostic Plot RN-01**

X-Plot analysis of the RN-01 well shows that the well has a slope that indicates the layering of permeability variation.

![X-Plot RN-01](image)

**Figure 3. X-Plot RN-01**

Based on result of Decline Curve analysis, the life-time forecast of RN-01 wells can produce until 29 January 2015. This can confirm that RN-01 wells are no longer economical in oil production so that conclude that RN-01 wells can convert to injection wells.
production was very low while water production was high which indicates a problem.

**Figure 4. Qo vs Time RN-01**

After being converted into an injection well, an analysis of the rate of water injection and well pressure in the RN-01 well showed that the improvement of the well was normal.

**Figure 5. Water injection rate and pressure vs Time RN-01**

This analysis also supported by the results of Hall Plot this analysis also showed that the well was stable.

**Figure 6. Hall Plot RN-01**

**WELL RN-02**

RN-02 well showed production started in October 2007 at an oil production rate of 224 bbl/day, water production rate of 512 bbl/day and water cut by 30%. Production at the RN-02 well lasted until May 2012 with an oil production flow rate of 2 bbl/d, water flow rate of 1907 bbl/day and water cut 95%. In February 2010 there was a drastic decline in oil production and in September 2011 oil production was very low while water production was high which indicates a problem.

**Figure 7. Production Rate vs Time RN-02**

Using Chan’s Water Diagnostic Plot, shows that well RN-02 has multilayer channeling as shown below:

**Figure 8. Chan’s Diagnostic Plot RN-02**

X-Plot analysis of the RN-02 well shows that the well has a slope that indicates the layering of permeability variation.

**Figure 9. X-Plot RN-02**

Based on result of Decline Curve analysis, the life-time forecast of RN-02 wells can produce until 8 Juni 2012. This can confirm that RN-02 wells are no longer economical in oil production so that conclude that RN-02 wells can be convert to injection wells.
After being converted into an injection well, an analysis of the rate of water injection and well pressure in RN-02 well showed that the well pressure increases in the beginning but in September 2018 the rate of water injection was very high but the increase in well pressure was low which indicates a problem.

This analysis also supported by the results of Hall Plot analysis which showed that the well have negative skin or injecting above parting pressure.

WELL RN-03
RN-03 well showed production began in July 2007 with an oil production rate of 2839 bbl/day, water production rate of 0 bbl/day and water cut by 0%, production at the RN-03 well lasted until December 2019 with an oil production flow rate of 0 bbl/d, water flow rate of 1266 bbl/day and water cut 100%. RN-03 showing normal decline oil production but the water production are high.

Using Chan’s Water Diagnostic Plot, shows that well RN-03 has Normal Displacemet with High WOR as shown below:

Based on result of Decline Curve analysis, the life-time forecast of RN-03 wells can produce until 28 April 2019. This can confirm that RN-03 wells are no longer economical in oil
production so that conclude that RN-03 wells can be convert to injection wells.

![Figure 16. Qo vs Time RN-03](image)

After being converted into an injection well, an analysis of the rate of water injection and well pressure in the RN-03 well showed that the improvement of the well was normal.

![Figure 17. Water injection rate and pressure vs Time RN-03](image)

This analysis is supported by the results of Hall Plot analysis which showed that the well was stable.

![Figure 18. Hall Plot RN-03](image)

CONCLUSION

1. By using only production data, monitoring and evaluating wells can be done effectively.

2. To find out the problems that occur in a production well that has high water production problems we can analyze by plotting between production rate vs. time to find out the production capabilities of the well. X Plot can be used to evaluate waterflood performance and diagnose layering in multilayered systems, Chan’s Water Diagnostic Plot is also used to analyze water behavior problems in wells, otherwise Decline Curve Analysis is used to determine the production age of the well until reach its economic limit rate and Hall plot method is used to analyze injection performance at injection wells.

3. The RN-01 and RN-02 wells has Multilayer Channeling and RN-03 is Normal Displacement with High WOR.

DAFTAR PUSTAKA