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Success Story of Optimization Low-Quality Reservoir in "R" Field at WK Rokan by Deliver Inclining Field Production Performance

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Abstract. Improving recovery in complex multilayer reservoirs of the mature oil field is one challenging task, particularly for those comprising various reservoir qualities with lateral heterogeneity characterization. Rigorous evaluation is required to define the best approach for production from the reservoir level into wellbore completion strategy. The sand with high quality would have significantly distinct flow performance compared to low quality with low permeability, which impacts artificial lift and perforation strategy design.

Some common issues found were low rates, crossflow due to commingling perforation of contrast reservoir quality, where low-quality one could not contribute fluid production that sometimes by pressure difference block or permeability contrast. This paper undertakes this issue and discusses a case study of "R" field optimization strategy to improve production in the low-quality reservoir.

"R" field is in primary recovery and characterized by two types of sand, high quality-permeability sand (HQ) and low quality-permeability sand (LQ). Most of its production comes from the HQ ("MT_R" and "BT340") and currently contributes to high water cut. On the other hand, oil from LQ with lateral permeability variations is unable to be produced optimally, especially when LQ is comingle with HQ, and opening LQ itself will be difficult to deliver fluid production. Lookback show LQ has low PI and is only able to produce with fracturing methods or commingled with HQ Sand.

The full-field subsurface evaluation was conducted including detailed rates by reservoir perforation to acquire and confirm alignment between production and geological data, for instance, pay and permeability data. It has resulted in a new workover strategy to optimize "R" field including commingling several LQ, and reactivation of LQ at long-term closed wells.

Pilot tests of commingling several layers of LQ usefully added fluid production with a low-rate pump and proved to successfully deliver a good workover result. Pilot tests were conducted at R#07, R#17, and R#39 with average fluid production of ~550 BFPD. The 1st batch workover produced oil gain ~300 BOPD and reduced fluid by 1,800 BFPD. The strategy has gradually been applied throughout the "R" field following lessons learned and success workover.

The new strategy has been implemented in three perforations and six reactivations. The collaborative effort successfully improves underperforming wells and puts the long-term closed wells back to life. It delivers inclining field production performance with incremental oil up to 943 bbl/day, water shut-off ~4,500 BFPD from active wells with >70% success ratio.

Bypassed oil from the LQ reservoir can be optimally produced by commingle several layers of LQ using a low-rate pump. Added value not only optimizes the underperformed wells but also better utilizes idle wells by unlocking the reactivation opportunities. This strategy has the advantage of delivering R2R2P through simple workover with cost-effectiveness.

Keyword(s): Low-Rate, Low Quality Reservoir; Optimization

1 Introduction

This paper will focus on "R" Field as one of the primary fields in PT. Pertamina Hulu Rokan.
"R" Field has been exploited for almost 47 years. It is a mature field with decline in oil production rates. Significant deviation or rapid decline can be caused by development history (natural withdrawal from base business activities and infill development), increasing water cut or decreasing productivity.
Prior the new well drill in 2022, the latest drilling in "R" Field was in 2013.
Improving recovery in complex multilayer reservoirs of the mature oil field is one challenging task, particularly for those comprising various reservoir qualities with lateral heterogeneity characterization. "R" Field characterized with 2(two) type sand, the high quality reservoir (permeability above 1000 mD) and the low quality-permeability sand (permeability much lower than 1000 mD), however most of its production were from the HQ type from MT_R and BT340 which currently contribute high water cut, on the other hand several layer LQ sand with lateral permeability variation were not optimally produced, even more when comingle together with HQ sand, and opening LQ itself will be difficult to deliver fluid production.
Some common issues found were low rates, crossflow due to commingling perforation of contrast reservoir quality, where low-quality one could not contribute fluid production that sometimes by pressure difference block or permeability contrast. With high water cut from HQ sand, it impacted declining workover gain results and low oil production in the recent years. Meanwhile LQ reservoir still has low recovery and bypassed oil. The objective of this paper is to undertakes the issue and discusses a case study of "R" field optimization strategy to improve production in the low-quality reservoir. LQ sand not optimally produced due to difficult to be managed and has complexity to deliver fluid production. Rigorous evaluation and comprehensive subsurface review in reservoir framework level until well level is required to define the best approach for production from the reservoir level into wellbore completion strategy to improve "R" Field Recovery especially from Low Quality Reservoir.

2 Methodology

Reservoir Management Review framework from field to reservoir and to well level is required to provide an optimization strategy for the complex multi-layer reservoir and deliver an opportunity to improve "R" Field Recovery especially from low quality reservoirs.

Reservoir Management Review Framework – "R" Field Review

2.1 Level 1 – Field Level

"R" Field located at Palas area consist of 47 wells, 49% well were active. In 2020, most of producers active were located at main attic "R" Field (southern part) while only 2 producers active on northern part.

2.1.1 Geological Background

"R" field is medium size elongated plunging anticline structure with three-way dip closure bounded at the west by a southwest major high-angle reverse fault. Consist of 4 cycles sedimentation deposition led to relative sea level rise and fall in early Miocene in "R" field that product sedimentation of MT_R, NB, BT, and R Fm.

2.1.2 Production Profile, WOR, Cumulative Production

More than 80% of cumulative production were coming from N formation (high quality reservoir). Peak production was in early stage of development in 1976 ~33 MBOPD. WOR has been increasing since November 1990 due to intensive workover, add commingle zones and size up activity (mostly from high quality reservoirs). It caused MT_R Formation has high RF meanwhile NB and BT still have very low recovery.

2.1.3 Production Mapping

Based on production mapping, most of active producers were located at main attic "R"Field (southern part) while only 2 producers active in the northern part. Most well in flank were already long-term closed.

Meanwhile good oil producer was in main attic area. More detail review is required for wells that underperformed, wells with low cumulative and the wells that were long term closed.

2.2 Level 2 – Reservoir Level

"R" Field has 4 main formations which are MT_R, NB, BT, and R Fm.
NB is divided into three reservoirs and BT is divided into seven reservoirs include BT 340. BT 340'sd and MT_R (HQ) are main productive sand with good sweep efficiency, the opportunity still exists at southern attic, while other area is relatively wet. The other reservoirs have low quality, lateral permeability variation that cause ineffective efficiency impacted low recovery (LQ). Detail stratigraphic correlation on flow unit for LQ is required to localize the sand distribution.

2.2.1 Reservoir Property

Detailed 2D conceptual geological model is generated from cross section (lateral reservoir continuity and connectivity, compartmentalization, structural geometry, COWC from new well, etc.). Annotation such as surveillance data, last welltest, watercut, PI, current open perforation can be marked in the model to visually show references and potential opportunities.
HPT Map, permeability map and net sand map is also being generated and analysed to understand the reservoir. Identification and characterization of all single reservoirs in the field and of their overall physical properties is being performed.

2.2.2 Data Validation & Analysis

Data validation is performed by history match surveillance data (for instance swab) with actual production data. It is to define productivity index by reservoir perforation, probable reservoir contributor and its allocation to the actual production (if comingle).
Reservoir performance analysis then being performed by integrated the historical production chart, historical workover job results and data validation. Analysis and interpretation of the past behaviour of all reservoirs is very important. Decline rate, prospective reservoir based on its historical performance and reservoir combination for comingle production scenario can be analysed and become one of the justifications for the optimization plan.
For long term close wells, water control diagnostic plot is being generated and analysed to understand the reservoir flow behaviour and determined the mechanism of excessive water production that happened. If it indicates bottom water conning behaviour, there is opportunity it was segregated after long term closed.
Most recent surveillance and historical workover lookback whether its success or failed will give lesson learned that will be very valuable value to the evaluation.

2.3 Level 3 – Well & Completion Level

After analyzing the reservoir level, the opportunities are identified. The prospective reservoir perforation to be opened or closed and reservoir combination completion strategy (if comingle) can be decided.
Reservoir perforation intervals should be carefully selected from prospective low-quality reservoirs (permeability less than 300 mD) which expected to have bypassed oil. Full body perforation can be implemented if necessary to accommodate sufficient rate.
After determined reservoir perforation intervals, productivity index and detailed rate for each reservoir perforation estimation is required, to acquire and confirm alignment between production and geological data for instance, pay and permeability data. The estimate oil rate from each reservoir perforation intervals should also give economically contributions.
Total production rate estimation should be accommodated by using low-rate pump for instance P4 with range 400 BFPD – 600 BFPD.
Rate simulation and sensitivity is performed to ensure the completion strategy and to bring optimum oil gain.
Based on the sensitivity, it confirmed that comingle the reservoir perforation with similar PI from low reservoirs gave more oil compared to commingle LQ with HQ (higher water cut). It avoids crossflow (due

to contrast reservoir quality and permeability). It also allows each reservoir perforation equally contributed to fluid production. Meanwhile single reservoir perforation interval will give very low production rate.
In term of perforation gun, ultra-deep penetration gun or regular gun with more SPF (for instance 8 SPF) is preferred and is expected to give better impact for LQ perforation.

3 Application

The methodology and reservoir management framework then being applied. Based on the integrated evaluation and full section from North to South, MT_R and BT 340 are two good reservoirs in term of sand quality, connectivity, and permeability, while other reservoir was relatively tight reservoir that had spatially heterogeneity. Based on previous lookback, HQ (MT_R formation) already wet in the northern and central section.
In the northern area, one of the wells (R4) open comingle from four LQ of BT formation with welltest ~85 BOPD/ 84% watercut. Refer to R4 and due to HQ (MT_R) northern-central area was interpreted as already depleted (wet), HQ at the northern should be isolated and focus on the LQ reservoirs. Low-quality reservoirs were being evaluated based on the geological model and historical data. Based on the latest resistivity, SWC data within the wells and support with typical type log of surrounding data, it still indicates remining oil in the prospective LQ reservoirs.
Trial then was conducted at R17 to isolate HQ (MT_R formation) and revisit three LQ reservoirs that historically have good watercut. Trial at R39 LTC wells also conducted to revisit LQ (BT350) and add new perforation of LQ (BT200, and BT350). It resulted good oil gain (Table 1).
Following the success of R04, R17 and R39, the northern well could be applied for comingle LQ strategies from the prospective low-quality reservoirs.
In the central, since HQ (MT_R and BT340) also already showed high watercut, the reservoirs were proposed to be isolated especially for the wells that located in the flank area and to revisit prospective LQ reservoirs. Trial was performed at R07 to isolate HQ (MT_R formation) and revisit two LQ reservoirs that historically have good watercut (BT330 and NB360 reservoirs).
Meanwhile in the south area, since HQ (MT_R) was no proven oil at R5 based on previous WO, it is proposed to be isolated and proposed to revisit prospective LQ intervals. One of the well from the flank (R14) was long term closed with several LQ open. Production history and diagnostic plot also has been analysed and it is proposed to be reactivated using the latest completion through simple reactivation. Result of the trials can be shown at Table 1 below.

Table 1. Trial for LQ Optimization

Closure	Well	Job Type	Recommendation	Result
North	R17	Underperformed well improvement	Isolate HQ and comingle LQ	118 BOPD/511 BFPD/78%
North	R39	Reactivation	Revisit and reperforate LQ	147 BOPD/441 BFPD/68%
Central	R07	Reactivation	Isolate HQ and revisit LQ (comingle)	82 BOPD/614 BFPD/87%
South	R14	Reactivation	Revisit LQ (comingle)	113 BOPD/740 BFPD/85%

Following the success of the trials from each closure, it proposed to expand the strategies to the surrounding wells especially for underperformed and LTC wells. Based on the full field reservoir framework and integrated evaluation, it resulted in a new workover strategy to optimize "R" field including comingle several LQ, and reactivation of LQ at long-term closed wells.

4 Result

The new strategy has been implemented in four underperformed wells improvement and nine reactivations throughout northern to the southern area with good result. The collaborative effort successfully improves underperforming wells and puts the long-term closed wells back to life.

It delivers inclining field production performance with incremental oil up to 943 bbl/day, water shut-off ~4,500 BFPD from active wells with >70% success ratio.
Further, there would be more opportunities for the next batch that are already in rig schedule for work over, reactivation from long-term closed wells, and opening new zones that have never been perforated that expect to improve production recovery of “R” field especially from LQ Sand.

5 Conclusion

Integrated Full field subsurface framework and production data analysis is an excellent way to identify opportunities and led to a completion strategy. By analyzed historical performance and interpretation of the past behavior of all reservoirs combine with completion history of each well carefully will capture opportunity that probable will not be captured by only evaluate current well performance and configuration. Bypassed oil from the LQ reservoir can be optimally produced by commingle several reservoir perforations of low-quality reservoir using a low-rate pump. Added value not only optimizes the underperformed wells but also better utilizes idle wells by unlocking the reactivation opportunities. This strategy has the advantage of delivering R2R2P through simple workover with cost-effectiveness.

4.1 Lesson Learned

- “R” Field inclining production shown the successful evaluation and implementation of the strategy to improve recovery of low-quality reservoirs.
- Full body perforation at LQ had usefully to add fluid production and give adequate rate with low-rate pump

4.2 Best Practices

- Perform pilot test to prove the oil productivity and production performance
- Focusing expansion on proven sand and area based on pilot results and integrated evaluation of geological and production data
- For reactivation candidates, materials and surface facility preparation prior execution is important to avoid delay put on production
- Collaboration between Asset Optimization Team with IODSC Team, Drilling & Completion and Operation lead to faster and safer execution and put-on production

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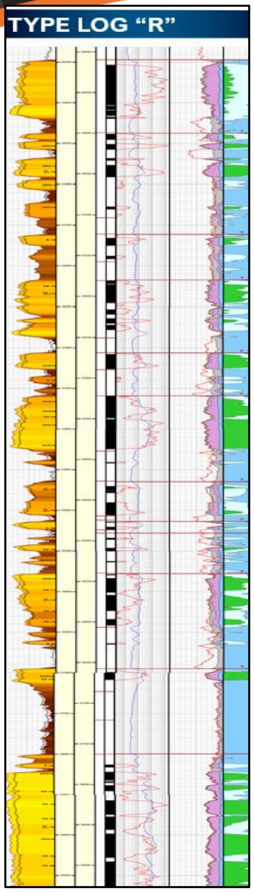

Figure 1. Type Log “R”

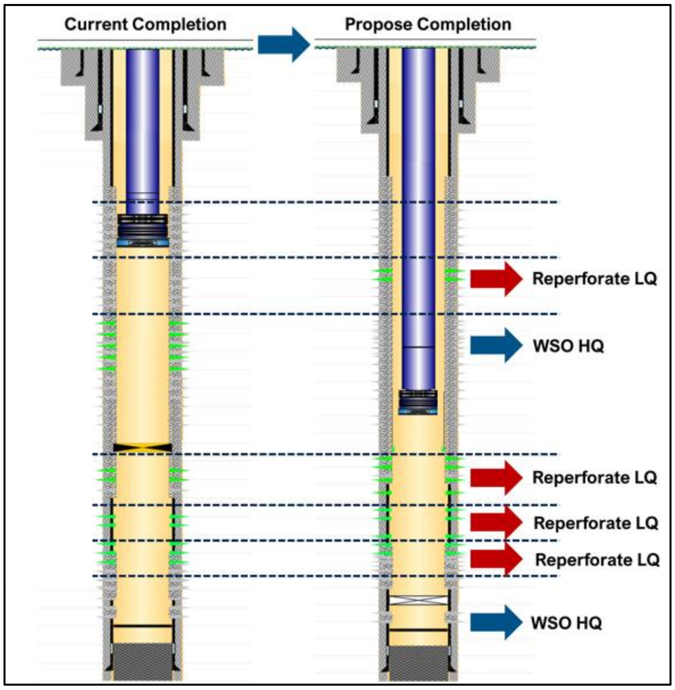

Figure 2. Completion Strategy

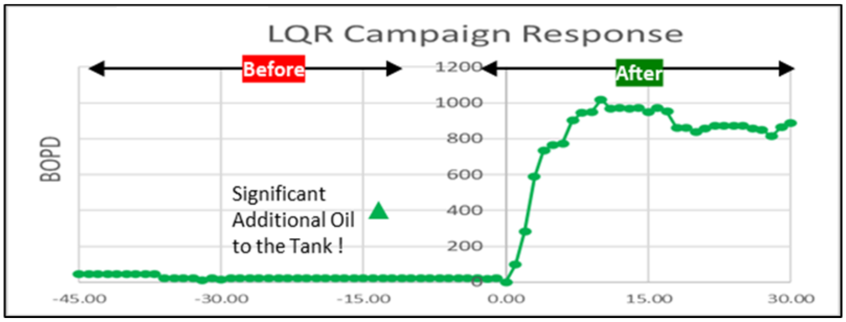

Figure 3. Excellent Result Focus on Low Quality Reservoir