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Subsurface and Surface Optimization Effort to Double Oil Production: A Case Study from Permata Field, Rokan Block

Hendri Kurniawan[1], Aulia Pradana[1], Aulia Sherly Safarina[1], Christien Lukito[1], and Hendro[1] Tjahjono
[1]PERTAMINA HULU ROKAN
* Email: hendri.kurniawan@pertamina.com

Abstract. Permata Field is a small field that located in Rokan block, Central Sumatra Basin. Permata field discovered and produce since 1977 with current recovery factor 37%. Permata field previously only has 2 - 4 active oil producers with total oil production around 160 BOPD.

To increase oil production in this mature field, several efforts conducted to tackle subsurface and surface issues. Subsurface issues consist of maintaining field reservoir pressure, existing well produce with high water cut, and inactive horizontal well already water out. While surface issue is the produced water that has reached the maximum temperature limit and the water discharge permit limit. Collaborative effort between subsurface team and surface team is needed to resolve the issues and maximize the oil production opportunity from Permata field.

Reservoir management optimization program is launched to address subsurface issues by subsurface team. The optimization program includes natural dump flood review, fluid optimization strategy, and Horizontal well upside potential low quality reservoir assessment. Surface operation teams also launched Permata GS improvement effort to resolved water handling limitation issues. The effort is conducted with pit/cooling pond upgrade and installed additional 3 aerators to reduce water temperature.

The collaborative effort from both teams successfully boosts oil production more than double to average ~400 BOPD.

Keyword(s): Production optimization; reservoir management optimization, natural dump flood, low quality reservoir, collaborative effort.

1 Field Overview.

Permata Field located in Rokan block, Central Sumatra Basin and its located 20 km southeast of Duri Field as shown in figure 1. It's a small field that discovered and started production since 1977. Permata Field reach its peak production of 4,730 BOPD in 1988. And after more than 40 years of production, Permata Field oil recovery factor already reaches 37%.

Permata Field has drilled a total of 9 wells in which only 2 wells are horizontal wells (Permata #08 & #09), while the rest are vertical wells). On the 2020 – 2021 period before the collaborative improvement effort conducted, only 2- 4 wells that active and contributed to field performance (2 wells already abandoned and 3 other wells are idle). At that period, Permata Field oil production was around 160 BOPD. Permata Field

production combines with the production of Pena field & Banga Field, goes to Permata Gathering Station (GS).

Permata field on the sub surface structure perspective is 4-way dip closure with elongated anticline trending NW-SE (figure 2). It consists of 4 main oil reservoirs from Bekasap Formation (2 sandstone lobes: A upper & lower sd and B sd) and Bangko Formation (2 sandstone lobes: C sd & D sd) as shown in figure 3 of Permata #01 log plot. It has good structural conformance from Bekasap down to Bangko and all wells drilled along the anticline axis.

2 Field Challenges and Improvement Effort

As a mature field, Permata Field has several issues or limitation in the sub surface and surface aspects. To improve its performance, several optimization efforts from both aspects need to be conducted.

Subsurface issues consist of:

- Maintain Field Reservoir Pressure
  From the 4 main reservoir, A sd, B sd, and D sd has great potential with high OOIP. A sd and B sd has lower RF than D sd. RF A sd currently 39% while B sd 10% compared with D sd that already above 40% RF and that makes A sd & B sd as higher priority to be reviewed further. Pressure data trend in A sd and B sd indicates no significant drop (only 15% - 20% decline) in pressure compared to its original condition which means it has strong support that need to be verified.
- High water cut
  Existing wells on Permata field that has good production performance (above 50 BOPD production) are Permata #01 and Permata #03 already produce with 98% WC. While Permata #06 and Permata #09 have higher WC of 99%.
- Inactive horizontal well
  The inactive horizontal well is Permata #08 that previously produce from A lower sd and has been idle since 2015. Both horizontal wells in Permata Field are targeting B sd, but both wells already close its lateral section since 2011 due to water out (close to 100% WC production from B sd).

While issues in the surface related to the limitation of Permata GS. Permata GS applies surface discharge as a method to handle produced water that has reached the maximum temperature limit (113 deg F; 24,000 BWPD) and the water discharge permit limit. That limitation often makes several wells that has high fluid and low oil production to be shut off as a trade – off to ensure daily GS operation within permissible limit. Collaborative effort between subsurface team and surface team is needed to resolve the issues and maximize the oil production opportunity from Permata field. Sub Surface Optimization team launch Reservoir management optimization program to address subsurface issues, while Surface operation teams also launched Permata GS improvement effort to resolved water handling limitation.

2.1 Reservoir management optimization program

The Reservoir management optimization program includes natural dump flood review, fluid optimization strategy and horizontal well upside potential low quality reservoir assessment.

2.1.1 Natural Dumpflood review

Dumpflood in Permata Field already occurred unintentionally from 2011 to A sd & B sd. Dumpflood most likely occurred at idle well Permata #05 where all zones were opened. Water from X sd flows to A & B sd as shown in figure 4. In MBAL simulation, after connecting oil target tank with water source tank X sd simulated pressure can match with overall pressure data, including the X sd itself. From pressure trend

(figure 5), Dumpflood impact clearly shown compared to the steady pressure increase from aquifer. Unfortunately, due to Permata #05 has packer plug above perforation, team could not conduct surveillance (spinner survey) to validate flows distribution to each sand.

2.1.2 Fluid Optimization Strategy

2.1.2.1 WSO & Single Zone Strategy

Permata #06 previously produce commingle from A sd and D sd with high fluid rate around 4.000 BFPD and high WC of 99%. It is suspected that D sd contributes a lot of water without significant oil. Based on above natural dumpflood review, it is suspected that dumpflood already occurred that target A and B sd (figure 6), so it is necessary to confirm the opportunity in A sd & B sd. Team also finds CO log data run in early 2019 that indicates there's remaining potential in B sd. Well Intervention are as follows: (1) water shut off by isolate existing D sd with packer, (2) open B sand to assess its performance by conducting swab, and (3) produce single A sd or B sd.

Well Intevention program resulted swab data as follows: A sd has good PI (Productivity Index) of 1,83 with good WC of 95% while B sand has low PI of 0,47 but better WC of 88%. After reviewing the swab data, team decided to isolate B sd & D sd with packer and produce single A sd. Permata #06 POP with 145 BOPD with around 3.200 BFPD. In the following months, the production stable at around 100 BOPD (figure 7).

2.1.2.2 *Size Up*

Permata #01 is an active well in Permata field that has very good performance of 2,982 BFPD / 67 BOPD / 98% WC with P23 pump (1200-2900 BFPD). It produces from commingled A sd and C sd. Its Fluid over Pump (FOP) around ~2,100' and pump already on upthrust condition, so the team proposed to size up and increase oil production. The job resulted production of 3.889 BFPD / 94 BOPD / 98% WC with Flex47 pump (2400-6000 BFPD). In the following months, the production trend increases to around 4365 BFPD / 120 BOPD / 97% WC (figure 8). Confirming the good result of high reservoir pressure maintained from the natural dumpflood.

2.1.3 HZ well upside potential low quality reservoir assessment

Horizontal Well Permata #08 has been idle since 2016 (HZ section B sand already water out). It is located at SE Closure of Permata Field. Based on review, Bekasap A sd develop in all well but with variation on reservoir quality and find indications of remaining oil potential in low quality reservoir (LQR) based on log (GR-Dres), side wall core, and analog from Permata #03 (figure 9). Team recommends to open Bekasap A upper sand to unlock LQR opportunity at southern part of south closure and produce single A upper sand. Well Intervention job conducted in October 2021 and resulted very good IP Production of 145 BFPD / 143 BOPD / 1,5 % WC from the opened LQR A sd. In the following months, the production trend stabilizes to around 119 BFPD / 118 BOPD / 1,1 % WC (figure 10). Good result at Permata#8 will open opportunity to revisit same LQR target interval at Permata #09 in the future.

2.2 Permata GS improvement effort

Permata GS improvement effort conducted with the pit/cooling pond upgrade and install additional 3 aerators (figure 11) to reduce produced water temperature. The upgrade purpose is to resolve issue high temperature of water discharge. Upgrade pit / cooling pond at Permata GS conducted by concrete the pit soil and completed in May 2021. After the upgrade completed, successfully re-POP 2 wells on Pena Field, but failed to re-POP Permata #06 due to high temperature issue increase from 111 F to 116 F. The team

then install additional 3 aerator to reduce temperature and successfully re-POP Permata #06. Above effort gives space for Sub Surface team to freely conduct Well Intervention jobs previously mentioned.

3 Conclusion & Lesson Learned

3.1 Conclusion

Great collaborative effort among all stakeholders to implement Sub Surface - Reservoir Management Optimization Program & Surface – Permata GS Improvement Effort with existing limitation and delivered Permata Field more than double production (figure 12).

3.2 Lesson Learn

- Each field has its own opportunity and challenges, it is better to conduct collaborative effort to solve the issues & grab the opportunity
- Continuous effort for improvement such as natural dumpflood to maintain reservoir pressure and fluid optimization management to improve production (WSO and single zone strategy combined with size up on other well)

4 Figures

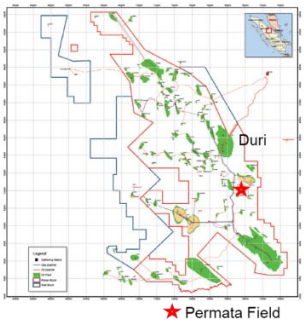

Figure 1. Permata Field in Rokan Block

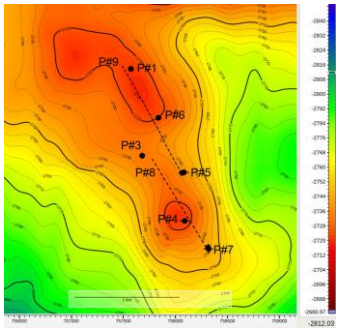

Figure 2. Permata Field A Depth Structure Map

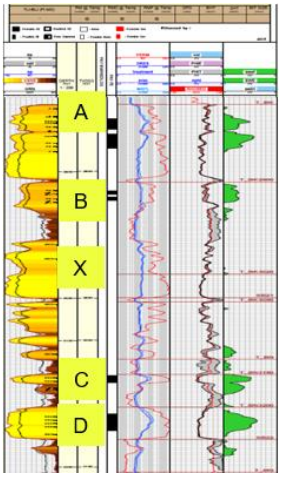

Figure 3. Permata Field Reservoir

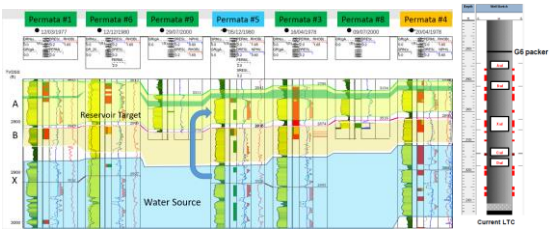

Figure 4. Permata Natural dumpflood Cross Section & Permata #05 completion

Figure 5. MBAL History Matching

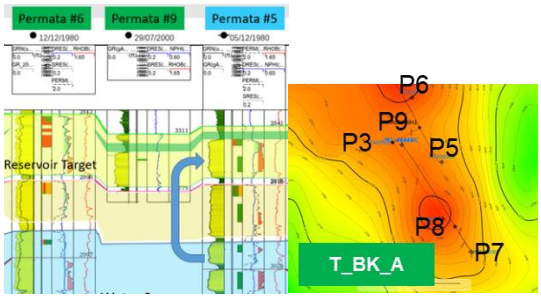

Figure 6. Permata #06 cross section and location

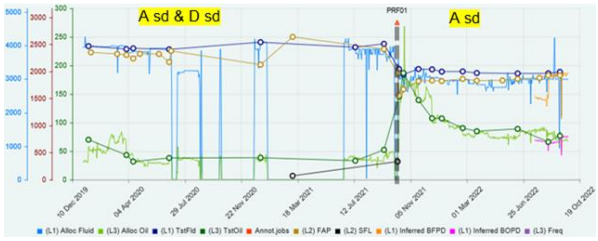

Figure 7. Permata #06 production performance

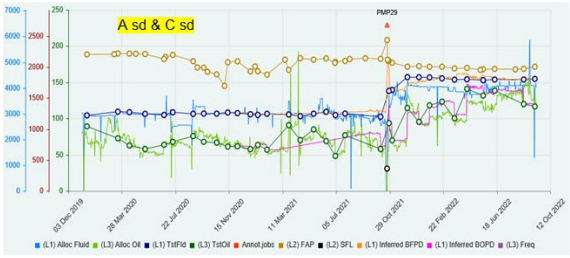

Figure 8. Permata #01 production performance

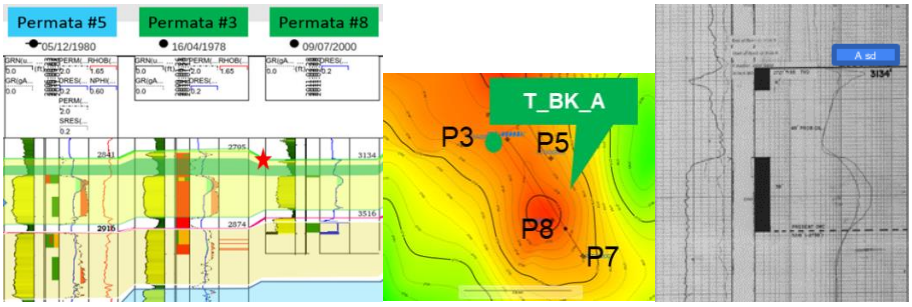

Figure 9. Permata #08 Cross section & Marked Log

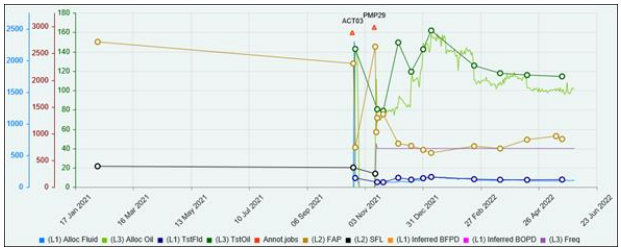

Figure 10. Permata #08 Well Schematic & Production performance

Figure 11. Permata GS Improvement Effort

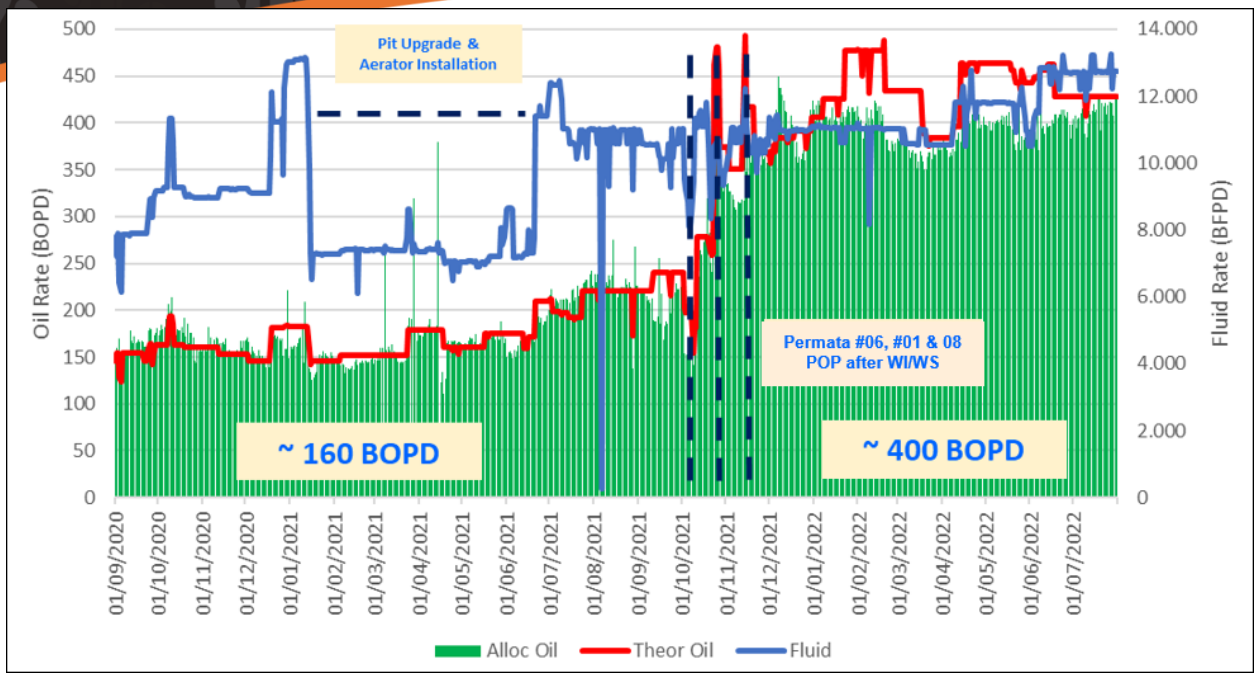

Figure 12. Permata GS Production Performance before & after optimization

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