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Successful Complex Thru Tubing Cementing and Sand Consolidation Operation in BL-x Mahakam, East Kalimantan, Indonesia

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Abstract. The Mahakam block, located in East Kalimantan, Indonesia, is operated by Pertamina Hulu Mahakam (PHM). Bekapai Field is one of those fields, and it has several wells that have penetrated the oil and gas reservoir. Some of them have a large oil rate and reserve, as well as good reservoir characteristics, such as high permeability and low swelling clay content. The zone must be opened due to the increased demand for oil. Sand consolidation is required due to the fact that it is an unconsolidated sandstone reservoir. BL-x case, access to the target zone was blocked by a fairly high sediment layer requiring sediment clean out/milling, and then another issue arises from the gravel pack zone, which is no longer producing and is thus cemented. There are two other unconsolidated reservoirs with cement gravel pack in the same packer zone that have good potential. It is challenging to place, and the reservoir has varying permeability, porosity, and clay content, but it is still an excellent candidate for sand consolidation treatment. On August 2021, the team successfully delivered a chain of complex operation, starting sediment milling for well accessibility, cementing using micro particulate cement to isolate zone behind gravel pack, until finishing the sand consolidation operation in the neighboring zone. The delivery added 1075 BOPD to the production stream, an excellent feat for 40-years old Bekapai field. In addition, it was carried safely amidst Covid-19 pandemic situation. This paper will elaborate on the experience of a successful complex operation that was carried out safely, as well as discuss in detail some of the measurable milestone achievements from the operation.

Keyword(s): Mahakam; Squeeze Cementing; Sand Consolidation; Milling; Complex Operation.

1 Introduction

Pertamina Hulu Mahakam operates in Mahakam Block which consists of four fields located in Offshore: Peciko, Sisi-Nubi, South Mahakam, Bekapai; and three fields located in Swamp: Tunu, Tambora, and Handil. Figure 1 shows illustration of fields under Pertamina Hulu Mahakam. Offshore well interventions are supported by accommodation working barges (AWB), supplied by third parties. These barges have a high-capacity crane which is used to lift up the well intervention equipment onto the platform's upper deck. Currently four (4) barges and two (2) remote operation are running in offshore campaign.

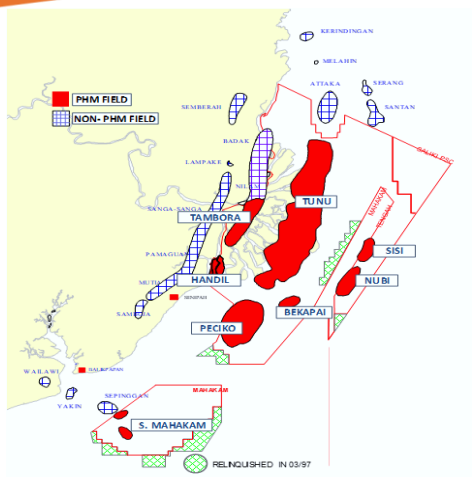

Figure 1. PHM Field in Mahakam Block

2 Bekapai BL-x Well

2.1 History and Planning

Bekapai Field is one of those fields, and it has several wells that have penetrated the oil and gas reservoir. Some of them have a large oil rate and reserve, as well as good reservoir characteristics, such as high permeability and low swelling clay content. BL-x is an oil and gas producer at Bekapai field which was completed on July 2007 with 4 zone cased hole gravel pack completion. In July 2018, a 3.75" QXH Plug was set at 1412.7 meter Below Rotary Table (mBRT). Above the plug there is open reservoir at 1230 – 1233 mBRT which is currently covered by sediment inside wellbore. Top of Sediment (TOS) was detected at 894 mBRT with 3.78" GC on 26th Aug 2020. Based on sample analysis, the sediment was not dissolved in acid and solvent. Sediment also did not react with PP indicator which narrow the suspect that sediment is coming from open reservoir.

Coiled Tubing (CT) is to running in hole to clean out sediment from last TOS down to top of QXH plug. Slickline (SL) then retrieve QXH plug to gain access to lower section of wellbore. All Sliding Side Door (SSD) are to be closed by SL. CT is then back with Thru Tubing packer to perform squeeze cementing to shut off Gravel Pack (GP) zone#2 at 1579.5 – 1583.5 mBRT and to cover next perforation target. Perforation need to be performed to unlock the potential of reservoir KU-y at depth 1564.5 – 1,566.5 mBRT and 1,568-1,569.5 mBRT,

2.2 Objectives

The objectives of the intervention is to perform squeeze cementing to GP zone#2 reservoir KU-i at 1,579.5 – 1,583.5 mBRT by using CT packer at at 1,544.5 mBRT and inject the treatment fluid via CT to reduce the treatment fluid contamination. Permanent bridge plug is located at 1,675 mBRT. This method enhances the probability to inject the sand control chemicals to the target zone. To increase well production, perforation needs to be performed to unleash the potential of reservoir KU-y at depth 1,564.5 – 1,566.5 mBRT and 1,568 – 1,569.5 mBRT. Reservoir KU-y is unconsolidated sand reservoir so in order to gain

sand-free production, Sand consolidation (SCON) chemical need to be injected to this newly perforated zone.

3 Complex Operation

Squeeze cementing thru GP zone and sand consolidation near/above GP zone are very rare in Mahakam. This job will take approximately 6 months, beginning in early March 2021 and ending in late August 2021. The achievement of the objectives in this well has been greatly aided by adequate and excellent preparation during the operation. The Bekapai BL platform is a platform that does not have a fixed crane so that prior to intervention, a portable modular crane is installed on the platform which is useful as a lifting device and set up unit from the AWB deck to the top deck platform (vice versa). The intervention unit was replaced and repositioned from the top deck platform and AWB deck several times due to the limited space on the top deck platform. If rely solely on AWB fix cranes, job may be delayed due to weather conditions in the offshore environment.

BL-x case as per mention above, access to the target zone was blocked by a fairly high sediment layer requiring sediment washing/milling, and then another issue arises from the gravel pack zone, which is no longer producing and is thus cemented. There are two other unconsolidated reservoirs with cement gravel pack in the same packer zone that have good potential. It is challenging to place, and the reservoir has varying permeability, porosity, and clay content, but it is still an excellent candidate for sand consolidation treatment.

3.1 Operation Sequence

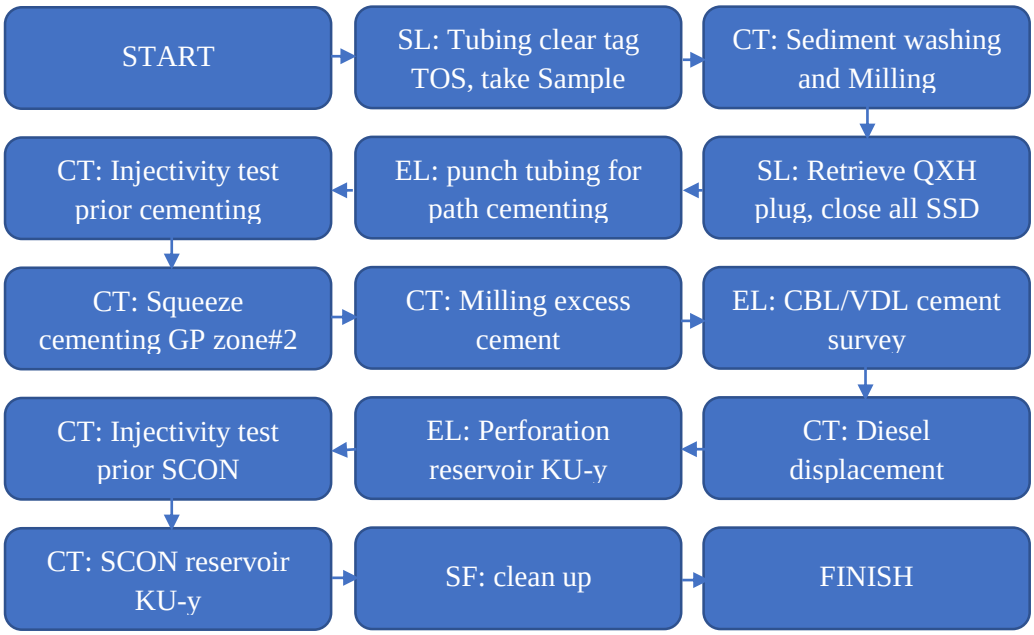

Figure 2. Operation Sequence of BL-x

Figure 2 shows a fairly complex sequence operation of an intervention work in which several challenging steps are carried out, such as the condition in the middle of the road when sediment washing reveals hard sediment, necessitating milling work, and then how far the milling is done so as not to damage the integrity plug that will be removed, not to mention the squeeze cementing to GP zone #2, which we know will be very tight given the propane in the exhaust. The contrast permeability of the two depth reservoirs to be sand consolidation must also be considered in order for the treatment to be optimal.

Table 1. Days planning versus realization

Job Sequence	Days Planning	Days Realization	Remarks
SL: Tubing clear tag TOS	1	1	
SL: Take sample	1	1	
CT: Sediment washing	7	9	*Loss Circulation event, Sequence SL and CT, need several milling mode, 12H operation due to Covid-19 case*
CT: Sediment Milling	7	21	
SL: Retrieve QXH plug	2	3	Need some bailing
SL: Close all SSD	3	3	
EL: Punch tubing	1	2	Tubing scrapper first
CT: Packer Injectivity test	2	5	Weather concern
CT: Squeeze cementing	2	4	Weather concern
CT: Milling excess cement	5	9	CT pipe and Milling BHA problem
EL: CBL/VDL survey	2	2	
CT: Diesel displacement	3	3	
EL: Perforation reservoir KU-y	2	2	
CT: Packer Injectivity test	2	6	BHA problem
CT: SCON treatment KU-y	2	2	
Waiting Curing Time	14	14	Crust Test achieved
SF: Clean up with sand filter	5	7	Tubing clear, PLT first
total	59	94	

Table 1 shows the work duration plan versus realization with some remarks of the concerns faced during the operation. There are many differences due to the uncertainty of the operation itself, not to mention the weather concern. An interesting concern that needs to be highlighted is that the Covid-19 case that had hit AWB had an impact on the availability of crew from all parties until it was finally decided to work in 12 Hours mode. Everything has been done with many considerations, especially from the safety aspect so that the operation continues to run until it gradually returns to normal operation 24 Hours mode.

Loss circulation event occurred at the beginning of the sequence when sediment washing/milling, lost circulation material (LCM) and filtered sea water (FSW) were pumped in batches. Rapid pressure drop

(1100 psi in 23 minutes) inside CT after squeeze cementing caused some quantity of displaced cement to surge into CT pipe. After unsetting CT Packer, fail to clean out all excess slurry inside CT at 1.5 bpm rate caused cement inside CT to be accumulated. When 6000 psi spike was observed inside CT, time window was already 25 minutes passed cement thickening time. Thus, hard cement was found inside CT and need to cut some meter of CT pipe prior next sequence. The bottom hole assembly (BHA) issue also occurred twice during CT job, preventing nonproductive time (NPT) from operating for a few hours, but this did not prevent the operation at BL-x from being completed safely.

Figure 3 shows the BL-x well diagram before and after operation, can imagine how difficult the operation would be with so much jewelry in this type of completion. The amount of jewelry available cannot be separated from the type of completion itself; unlike standard tubing less, where the jewelry and size of completion are almost identical from top to bottom and only have a different inside diameter (ID) on the nipple, GP well completion has a lot of jewelry as well as different ID sizes. Also, the outside diameter (OD) of the tool used must be adjusted. One of the cases highlighted in the BL-x well is the ID of the nipple above measuring 3.75" while the ID of the tubing below that will be accessed is 4.78", which is why we use an inflatable packer and under reamer bit for well access so that we can still access it. passes through a nipple with an ID of 3.75" and intervenes in a blank pipe with an ID of 4.78".

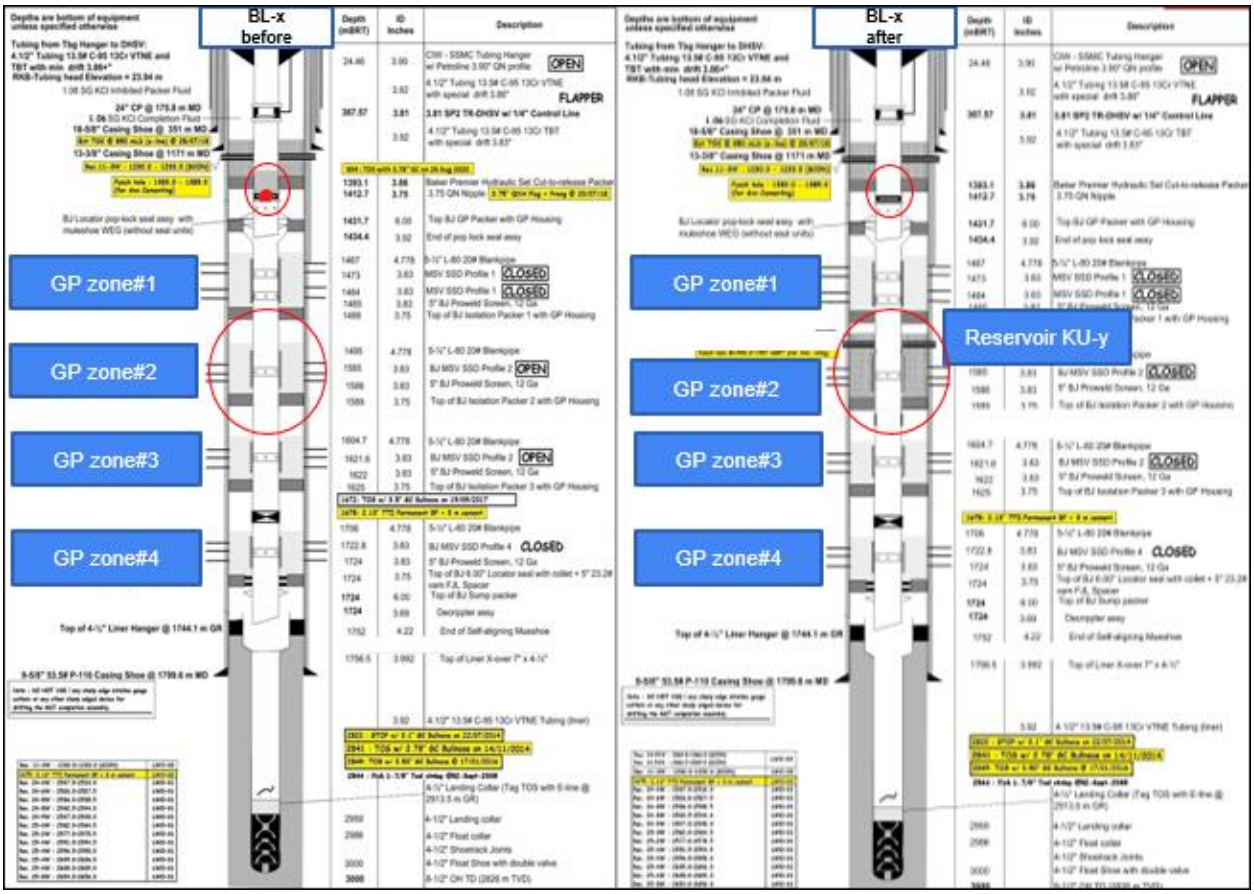

Figure 3. BL-x well diagram before and after intervention

3.2 Result

This job took a long time, as evidenced by the significant difference between the plan and the actual until finally in August 2021, the team successfully delivered a chain of complex operation, starting sediment milling for well accessibility, cementing using micro particulate cement to isolate zone behind gravel pack, until finishing the sand consolidation operation in the neighboring zone. The delivery added 1075 BOPD to the production stream, an excellent feat for 40-years old Bekapai field. In addition, it was carried safely amidst Covid-19 pandemic situation

3.3 Lesson Learned

While the operation was executed within expectation and without any major issues, few key lessons learned were captured and shared during post-job review.

1. The Covid-19 protocol is very important to always be applied during operation, the case that occurred at that time was due to negligence in implementing the protocol
2. The material and amount used in the LCM composition are critical in overcoming the predicted loss of circulation.
3. Bit selection is critical for good accessibility; in this case, we use standard junk mill bits to mix sediment above the plug and under reamer bits to mill cement below the target performance.
4. The type of cement used is also important in this job; we use micro fine cement that can enter the GP zone through propane, which is quite tight.
5. One of the mitigations for contrast permeability, the resin volume is added to adjust the smallest penetration in order to get a minimum penetration (3ft)
6. To emphasized on job program the importance of securing pressure inside CT after squeeze cementing to avoid cement surge into CT
7. Make sure the BHA back up should be tested before and recorded, and should be ready on board to avoid delay of operation

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