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Successful Performance of a New Domestic Sand Consolidation Product in Mahakam

Izzad Abidiy*[1], Fransisca Indah Permatasari[2], Erlangga Surya Dharma[3], Baida Iqlima[4], Tomi Sugiarto[5]
[1,4,5] PT Pertamina Hulu Mahakam, [2] Universitas Pertamina, [3] formerly PT Pertamina Hulu Mahakam
* Email: izzad.abidiy@pertamina.com

Abstract. Chemical sand consolidation (SCON) as an in situ sand control method by injecting epoxy resin to re-bind and strengthen formation sand grain has been a common approach to tackle sand production issue for more than decade. Recently, a new type of SCON made by the local is being develop in Mahakam fields which offers high performance and cost effective. The newly local sand consolidation was assessed in three different wells to validate the effectiveness in both consolidation strength and regained permeability of the new product. This study will present the successful history based on performance evaluation in the treated wells. The performance evaluation of the local sand consolidation is determined through lab testing as a pre-job preparation and post treatment result including top of sediment (TOS) increment and actual recovery. Several lab testing are performed to examined the resistance of resin fluid to pressure and temperature, that consist of curing time test, compressive strength test and permeability regained test. While the assessment of TOS increment is to ensure none of formation grain are bypass the resin consolidation into the wellbore after treatment. It is concluded that the local sand consolidation is field-proven by succeeded to increase formation strength over than 1000 psi of compressive strength while keep maintaining permeability near wellbore regained up to 90%. It was found only minimum of TOS increment at maximum rate 0.26 m/day. By using local resin-based sand consolidation, all treated wells able to produce sand free with average gas rate 2 million standard cubic feet per day (MMscfd) and recovered remaining reserve in shallow section.

Keyword(s): Sand Consolidation; domestic product; sand control; well intervention

1 Introduction

Mahakam block consist of several blocks of oil and gas producers. In general, the reservoir depth zonation was divided into main zone and shallow zone. Main zone was developed started from 1974 in Bekapai and 1990 in Tunu as the field milestone in Mahakam. The characteristic of this zone was sandstone formation with depletion drive mechanism. Consolidated zone in virgin reservoir, and medium probability of sand risk in depleted reservoir. Shallow zone was developed since 2009 in Tunu. It characterized with strong water aquifer with hydrostatic pressure drive and unconsolidated sand due to lower burial pressure than main zone. The study of zonation of sand risk reservoir was performed (Mukmin, 2018) in order to simplify field development in terms of sand control requirement.

Sand control was mandatory applied in well-defined unconsolidated sand reservoir. The purpose is in order to reduce risk of sand erosion and sand accumulation impact on surface and in the wellbore. Sand erosion especially at surface facilities exposes hazard to people safety as well as to environment. Sand accumulation exposes risk of stopping production and loss of opportunity to produce the hydrocarbon. Therefore, reliable sand control method is a must.

Sand control development in Mahakam was started since 2009 using gravel pack (Muryanto, 2018) and rig-conveyed stand alone screen completion (Laidlaw, 2014). Due to limited number of high stakes well and high cost of rig-assisted completion, the sand control strategy was switched to thru tubing sand control. One of the thru tubing sand control method was solvent-based resin sand consolidation, also developed since 2009 (Chaloupka, 2010; Chaloupka, 2012). Well completion targeting shallow reservoir was also switched to tubingless completion (Handoko, 2017). Sand Consolidation was successfully applied in several field in Mahakam, including Handil (Marisa, 2016; Hadi, 2019) and Tunu (Widarena, 2017).

Alternative sand consolidation method was also developed in parallel of the solvent-based method. Remedial sand agglomeration (Mahardhini, 2015), hybrid inorganic-organic chemical (Andrieu, 2018), and sand conglomeration (Styward, 2018) was also used in Mahakam. Chemical diversification was also performed in purpose as cost optimization strategy (Abidiy, 2020).

The current optimization study used in this paper is to use local sand consolidation product. Domestic manufacture will simplify supply chain process and also could minimize the operation cost. Objective of the study is to escort the utilization of domestic sand consolidation product by comparing all the parameter since the preparation stage until the result of the treatment to existing imported sand consolidation product. This paper will consist the methodology to evaluate the new domestic product. Then, it is followed by the implementation and result of the sand consolidation in general. The paper will be concluded on the end of the paper.

2 Method

The domestic sand consolidation developed on this paper was a solvent based resin, a similar resin system that used previously from foreign vendor. Overall methodology of the domestic product validation is by comparing all the parameter to the benchmark. The benchmark as per shown in the study of Widarena (2017) and Abidiy (2020) was the result of sand consolidation treatment that had already been used in Mahakam since 2009. But for the study purpose, the benchmark data use treatment result from 2018 to 2021 from existing sand consolidation product.

The initial stage of the product development is to have chemical mixture tested in laboratory to have the competent chemical properties in comparison to existing product that had been used frequently. The

chemical properties consist of chemical curing time, viscosity development profile, regain permeability and the compressive strength. By having similar chemical properties, the chance of having same result of quality is high (Abidiy, 2021).

The next stage of product validation is the production result that had been achieved compared to the result from the existing product implementation. The parameters were initial production rate and initial sand production rate. These parameters measure whether the implementation is successful or not.

The last stage of product validation is the lifetime of the treatment. The quality of the treatment was measured by how well the treatment can control the sand throughout the lifetime. The parameter used to measure the sand control capability is to measure the sand indication and accumulation monitored in the surface and wellbore. The sand accumulation in the wellbore is the novelty of this study since it will measure how the sand accumulated throughout the lifetime of the well.

The laboratory testing, the production result, the lifetime validation, and its comparison with the existing sand consolidation product could be described through a diagram on figure 1. The existing product data was taken on 102 cases. Meanwhile, the domestic product had already been implemented on 3 wells. The implementation of 2 different products was controlled by implementing in the same shallow zone Tunu field. The unconsolidated sand properties were confirmed by previous study using depth zonation (Mukmin, 2018). Therefore, it was considered there were no difference between the consolidation result between wells. The comparison between 2 products was considered fair apple-to-apple.

Cost comparison was not discussed in this paper. The reason was the price will be strongly dependent to supply and demand between the provider and the user during certain period. The only objective comparison was to compare the technical parameters as per discussed previously. Those parameter could be replicated to other user in any period.

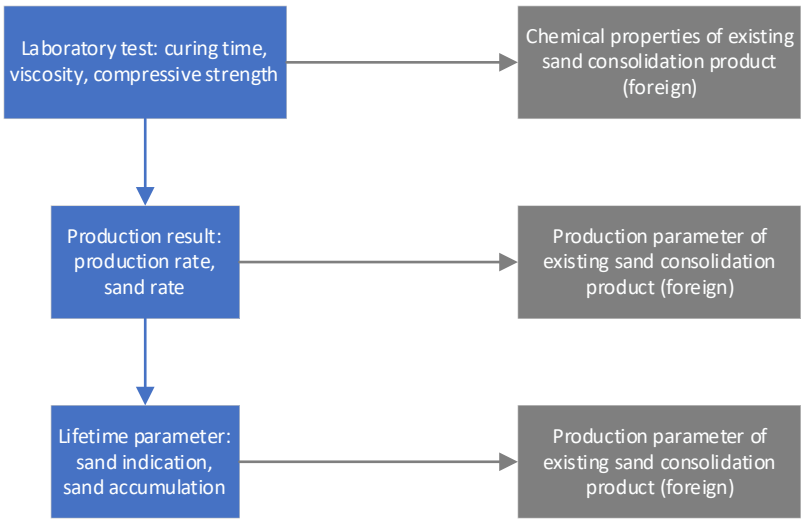


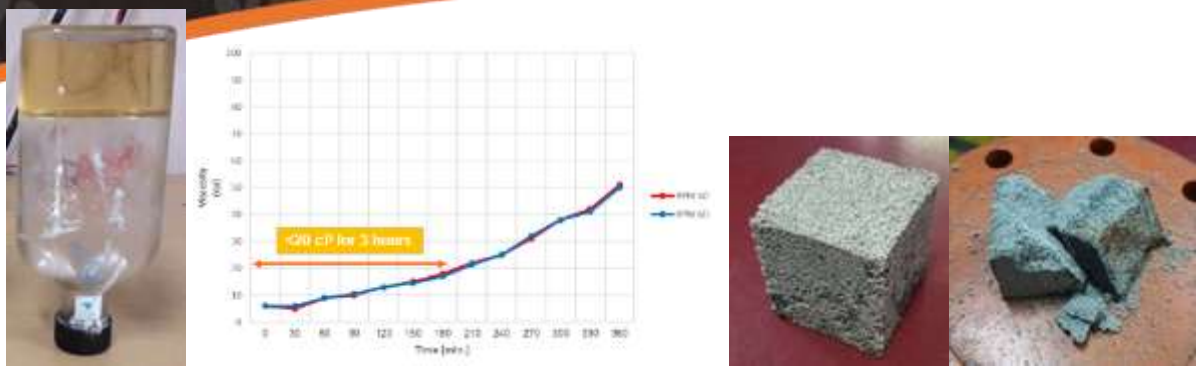
Figure 1. The workflow of domestic product validation.

3 Result and Discussion

The laboratory result is as per table 1. The curing time that performed approximately at temperature 70 degree celcius gave the result 6 hours to cure for existing product and 4 hours for domestic product. The earlier 2 hours did not give significant impact on the operation, since 4 hours pumping period was sufficient to deliver the chemical to reservoir. The viscosity test gave the same result between foreign and domestic product. The compressive strength result shown that the existing product strength was higher at 1600 psi compared to domestic product at 1200 psi. However, since the production was maintained at maximum 30 bar drawdown pressure, the 1200 psi compressive strength is still sufficient. The regain permeability test shown that the domestic product has higher regain permeability compared to existing product. This explain why the compressive strength is lower compared to existing product, it was likely due to the domestic resin "coat less" than existing product. For the further validation, the result of production and lifetime will justify the quality of the domestic sand consolidation. Figure 2 show the visual result of the laboratory test.

Table 1. Laboratory test result

Parameters	Indicator for resin	Existing Product (Foreign)	Domestic Product
Cure test (70 deg C)	How well the resin can cure and form a bond	6 hours	4 hours
Viscosity	How the resin could maintain the viscosity during high temperature exposure prior to transform into solid	5 cp	5 cp
Compressive strength	How strong the resin bond with the sand	1600 psi	1200 psi
Regain permeability	How free the hydrocarbon can flow along with the resin bond presence between the sand grain	80%	93%



(a) (b) (c)

Figure 2 (a) cure test result (b) viscosity test result (c) compressive strength result

Production result can be seen in table 2. showed that the initial production rate of exisiting product was still higher at 2.5 MMscfd compared to domestic product at 2 MMscfd. This rate was intentionally given due to lower compressive strength test result. However, from implementation on 3 wells, the gas recovery on domestic sand consolidation was higher compared to the average of existing product implementation. This recovery performance shown that the domestic product still gave the good production contribution.

Table 2. production result

Parameters	Indicator for resin	Existing Product (Foreign)	Domestic Product
Initial production rate	The production rate right after the well open after the sand consolidation treatment	2.5 MMscfd	2 MMscfd
Gas Recovery	The total gas volume recovered after sand consolidation treatment compared to the initial gas volume target	75%	88%
Produced Gas	The volume of gas production after sand consolidation treatment	0.35 BCF	0.22 BCF

The lifetime performance of sand consoldation could be seen in table 3. Compensating the low production rate of domestic product, the sand consolidation quality could be more elaborated with lifetime performance in terms of sand production. From the existing product experience, it was shown that the sand detection event occurred on 20% of the case sample during the lifetime of production. Meanwhile, surprisingly the domestic product result never showed the sand indication on surface.

In order to validate this data, the author wanted to validate the sand production up to the upstream side, which located on the wellbore itself. The parameter taken was the sand accumulation occurred on the wellbore. Since the data was extremely deviated, the sand accumulation then normalized with the lifetime of the well itself. The rate of sand accumulation per day explained the sand production rate that happened in the wellbore. Although this parameter was not exactly explained the regular sand production rate every day, for instance the sand break could happened in sudden event production high amount of sand, the sand break in bulk also could be explained by the sand production rate per day, spreading the bulk of produced sand in the lifetime of the production.

The sand production rate data showed that the domestic product produce significantly less sand at 0.16 meter/day compared to existing product at 1 meter/day as per seen on the second line of table 3. This parameter confirmed the lower sand indication at surface on domestic product.

Table 3. lifetime performance result

Parameters	Indicator for resin	Existing Product (Foreign)	Domestic Product
Sand detection at surface	Indication of physical sand presence at wellhead choke which indicate the sand consolidation failure at formation	20%	0%
Sand accumulation	Sand accumulation in the wellbore indicated by tagging depth in any period, normalized by devided with period between 2 sand accumulation depth tagging	1 meter/day	0.16 meter/day
Lifetime	The average period of the reservoir production, which is the period between the initial reservoir production and the date when the well died, either due to sand breakthrough or the hydrocarbon was fully recovered	190 days	130 days

The interesting fact was seen on the chemical-production parameter in comparison with the sand production rate. The lower production rate of domestic sand consolidation shown the carefulness of the product implementation due to lower chemical properties performance. However, that attention give the superior performance of sand failure guardiance. The gas recovery also gave higher portion of achievement.
Another room of improvement on this study is the intentionally lower target allocation for domestic product compared to existing product. The gap of produced gas and lifetime could be a potential point of data that sand break at bulk may occurred. The further validation need to be implemented on the higher gas volume to validate the superior performance on the sand control effectiveness.

4 Conclusion

The conclusion of this study as per following point:

- The chemical properties of domestic product still gave the good result, even some of the parameter is quantitatively lower than existing product such as compressive strength and initial production rate. The production parameter of domestic product was intentionally kept lower than existing product as a carefulness measure in order to maintaining the product works within its parameter.
- The novel parameter in measuring sand production rate in wellbore gave the validation for no sand detection on surface on domestic product. The non-occurrence sand break in bulk performance need to be validated in higher allocated volume of gas target.

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