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IPA19-E-310 PROCEEDINGS, INDONESIAN PETROLEUM ASSOCIATION Forty-Third Annual Convention & Exhibition, September 2019 SUCCESS STORY OF INCREASING OIL PRODUCTION AND SAND HANDLING PERFORMANCE BY PCP IMPLEMENTATION IN HEAVY OIL RESERVOIR UNDER CSS TREATMENT Dias Anugrah Massewa* Fahmi Nugraha* Ferdyan Ihza Akbar* Listiawan Febrianto* Nugroho Marsiyanto** ABSTRACT Heavy oil fields are notoriously difficult to produce. The main obstacles, namely but not limited to high viscosity and high pour point characteristics, augmented with sand problems. Batang field, located in Siak Block, is one of Indonesian heavy oil fields that is treated with Cyclic Steam Stimulation (CSS) to improve oil mobility, recovery, and prevent oil congealing below pour point. Nonetheless, sand accumulation in this field often causes high-pressure drop in the well due to friction or hydrostatic loss affecting the well to become unable to produce oil anymore. This problems lead to intensive pump recondition and sand bailing. This paper is focused on evaluating pilot Progressive Cavity Pump (PCP) implementation performance on four selected low priority wells, which previously utilized Sucker Rod Pump (SRP). The analysis includes oil producibility, sand handling performance, power consumption, and economic evaluation. Both pumps are known for 2the ability to perform under several ranges of high temperature environment and handle solid to some extent. Field data analysis 3were conducted in two periods. The first period was one year SRP usage (prior to PCP trial) and the second period was one year PCP implementation (trial period). During observation period, Batang field was producing with average of 1700 BOPD. The result shows that by using PCP, oil production from these particular wells increased by around 142 BOPD. Additionally, two out of four selected wells were successfully reproduced after long idle period due to severe sand accumulation rate. Besides, well service frequency was tremendously decreased from four to one activity in evaluation period, which effectively reduced operational cost through avoiding sand caused failure. From this study, PCP is successfully 1proven to be suitable artificial lift alternative in Batang field. INTRODUCTION Siak Block is located in Riau, Sumatera, Indonesia, which consists of Batang, Lindai, and South Menggala Field.

The field that is discussed on this paper is Batang Field, which has 1600 km² area. The challenges of producing oil from this field are mainly due to heavy oil (22.1° API), high pour point oil (75° F), high oil viscosity (1220.6 cSt at 100° F), and unconsolidated sand reservoir. Cyclic steam stimulation (CSS) or Huff and Puff method has been regularly applied in this field to maintain reservoir temperature thus prevent congealing and reduce oil viscosity. Additionally, bail out sand has been routinely performed to mitigate sand accumulation in the well. Previously, the Sucker Rod Pump (SRP) has been widely used in this field due to its ability to withstand high temperature, lift high viscous oil, and easily operated by field personnel. Yet, the downside of using SRP is limited sand handling performance that leads to extensive pump stuck, poor gas handling that leads to gas lock, and has well head leaks potential. SRP also has upstroke and down stroke movement which contributes to sand accumulation (Yaser Alnaqi, 2014). In order to overcome those problems, initiative to install alternative artificial lift method, which is Progressive Cavity Pump (PCP) as a trial, has been exercised in low priority wells. PCP has been known as appropriate artificial lift solution for heavy oil, sandy well characteristic, higher pump efficiency, and low power consumption (Bingchang Wu, 2010). Due to this field's sand abrasiveness and high temperature, the elastomer chosen for the PCP's stator is Hydrogenated Nitrile Butadiene, which is able to withstand abrasive sand and high temperature environment until at least 280oF. This paper explains the trial result, which is the differences between PCP and SRP performance in term of oil recovery, sand control, power efficiency, and economic evaluation. METHODS The analysis of performance comparison is divided into two periods, which were one year using SRP and one year after converting to PCP. The analysis is performed for each trial wells and field scale. Analysis Parameter The analysis is consisted of four parameters, which were performed for each trial wells. The first parameter is oil recovery, which was calculated by subtracting oil gain after converting to PCP with oil production during SRP utilization. The second one is sand control which was quantified by the amount of well service that were executed while utilizing SRP compared to after changing to PCP. Sand handling also shown by the ability

to reactivate producer well after idle period. The third one is power efficiency, which was comparing electrical power usage between SRP period and after PCP conversion. During SRP utilization, the voltage was constant and the monitoring of electrical current was performed monthly. Meanwhile, in PCP usage, voltage could be adjusted using Variable Frequency Drive (VFD) and the electrical power consumption could be read on the panel. Electrical power consumption data is taken monthly for all wells including the trial wells. The last one is economic evaluation, which was calculated by deducting the economic evaluation between PCP trial phase and SRP period. Trial Wells The PCP trial was installed to four selected wells which are Batang 22, Batang 32, Batang 43, and Batang 72. The main criteria of choosing the trial wells was low priority wells with idle condition such as Batang 22, Batang 32, and Batang 43. Additionally, alternative criteria of selecting trial wells was high production potential well with declining production such as Batang 72. Completion detail of these trial wells can be seen in Table 1. The completion diagram for each trial wells can be seen in Figure 1. Bail out sand is a standard procedure that must be performed during well service (pump recondition and upsize or downsize pump) due to high sand accumulation rate in this field. Yet, well services in all trial wells that have been accomplished prior changing to PCP are not considered successful due to still experiencing pump stuck in short time after well service. Huff and Puff is conducted to maintain agreed wellhead temperature, which is above 90° F to prevent oil congealing. Well head temperature is used as reference for monitoring well temperature because of the similar value between wellhead temperatures and well bore temperature due to typical shallow well and minimal temperature loss. Huff and Puff has been conducted in Batang 22 on 27 May 2017 and Batang 32 on 17 March 2017. Although not all trial wells were treated by Huff and Puff during observation period, these trial wells are located nearby wells that are regularly treated by Huff and Puff so the temperature of trial wells were still maintained to be above 90° F. The wells that are located nearby trial wells with their Huff and Puff activity can be seen in Table 2. RESULTS The analysis for oil producibility and sand control are explained for each trial wells and field scale. Meanwhile, power consumption

and economic evaluation will be performed in field scale. Trial Wells Analysis 1. Batang 22: Oil Producibility: Average production of Batang 22 has been successfully increased from zero BOPD (off well) to 15 BOPD after converting to PCP. In the previous SRP phase, Batang 22 has been idle for 8 months due to pump stuck problem and considered as off well. Huff and Puff was performed once prior changing to PCP on 27 May 2017 and effectively maintained temperature on 116°F. Production profile including well service and Huff and Puff activity of Batang 22 can be seen in Figure 2. Sand Control: Well service has been performed twice on 24 May 2017 for pump recondition and on 12 July 2017 for upsize pump. After converting to PCP well service amount has been reduced to only once on 27 January 2019 for PCP pump recondition, changing elastomer, and bail out sand. The problem found was torque drop with indication of declining production caused by elastomer of the stator was not perfectly sealing anymore due to wear out. Rotor and stator needs to contact each other to make seal between cavities. 2. Batang 32: Oil Producibility: After changing to PCP, Batang 32 average production increased from zero BOPD (off well) to 9 BOPD. Batang 32 has been idle for 8 months before converting to PCP. Huff and Puff was conducted once in SRP period on 17 March 2017, the wellhead temperature has been successfully maintained at 105°F during observation period. Production profile including well service and Huff and Puff activity of Batang 32 can be seen in Figure 3. Sand Control: During SRP phase, well service due to pump stuck has been conducted 3 times which consist of 2 pump recondition on 11 March 2017 and 26 May 2017 and 1 down size pump on 16 April 2017. After changing to PCP, well service was eliminated to zero due to no pump stuck or significant production decline found. 3. Batang 43: Oil Producibility: Average production increased from zero BOPD (off well) to 33 BOPD after installing PCP. Batang 43 was idle for 3 months prior to using PCP. During observation period, wellhead temperature was measured with average of 119°F so Huff and Puff was not needed yet to be applied in this well. Production profile including well service and Huff and Puff activity of Batang 43 can be seen in Figure 4. Sand Control: In PCP period well service due to pump stuck was successfully reduced from 5 times (SRP period) to 3 times. In SRP period, up

size pump was executed on 28 April 2017 and 30 May 2017 while down size pump was performed on 31 October 2017 and 10 November 2017. Pump recondition also has been performed on 8 December 2017. After changing to PCP, well service was reduced to only 3. The first one on 20 April 2018 was re-run tubing due to tubing connection lost at 2 joints below tubing hanger. Additionally lowering pump setting depth was performed from 306.14 ft MD to 409 ft MD due to low FAP (Fluid Above Pump). The second one on 19 May 2018 was re-run tubing due to tubing connection lost again at 3 joints below tubing hanger. The third well service which was on 19 June 2018 was fishing job caused by sucker rod string and pup tubing joint lost. Analysis was performed and high torque occurred between tubing and casing because the PCP type which was insert PCP could not withstand the high torque between tubing and casing. Therefore the PCP type was changed from insert to tubular PCP. In tubular PCP, tubing was anchored to the casing and the possibility of tubing unscrew was minimized. 4. Batang 72 Oil Producibility: Average oil production for Batang 72 increased significantly from 30 BOPD to 91 BOPD. Prior to converting to PCP, production of Batang 72 was constantly declining from around 90 BOPD on June 2017 to 0 BOPD on February 2018. Huff and Puff was conducted on 4 February 2018 and successfully maintained temperature with average of 142°F. Production profile including well service and Huff and Puff activity of Batang 72 can be seen in Figure5. Sand Control: Before PCP period, well service was done once to pull out tubing pump and bail out sand prior to huff and puff activity and changing to PCP on 21 February 2018. Rig less well service was performed once after converting to PCP for rotor replacement on 7 April 2018. There was an indication of bottom hole temperature drop in Batang 72 that gave shrinking effect to stator's elastomer. Therefore the rotor was upsized to suits the shrinking phenomenon of the stator. Field Scale Analysis Oil Producibility and Well Service In Figure 6, the yellow color indicates the additional production from PCP trial wells. The incremental production during PCP trial was averagely 142 BOPD from 4 trial wells. In term of well service frequency for trial wells prior and after converting to PCP, the number has been significantly reduced from 11 to 5 activity which gave us huge efficiency

for the operational expenditure. However, there was an additional concern that needs to be focused in regard with converting from SRP to PCP. Although the well service amount due to pump stuck was reduced, there was an indication that most of the sand is lifted from the well and flowed all the way to the gathering station where sand deposition build up rate inside the wash tank was getting faster. This indication could be seen during cleaning wash tank activity where the sand deposition was higher than it used to be after installing PCP. Power Consumption Besides boosting well production, PCP implementation also reduced the cost in terms of power consumption. By referring to Figure 7, there are huge power consumption in comparison between before and after PCP era. This situation occurred due to some factors such as motor power and VFD application. In Batang Field, SRP used 33 HP electric motor with no VFD and PCP used 46.2 HP electric motor at full load with the same supply voltage of 460 VAC. However, despite its huge power and same required supply voltage (460 VAC), PCP runs in control of VFD that adjust the power consumption depends on the operational needs. PCP works in control of VFD hence allows PCP to run at lower voltage and current (adjusted with required operation). Within surveillance, shifting from SRP to PCP has been reducing trial wells' power consumption up to 79% in average. Economic Analysis The factors that were contributing in economic evaluation were divided into three big parts. The first one was revenue which was the multiply result of oil gain and oil price. The second one was total cost or operational expenditure which was the summary of the cost for well service, tubing pump recondition, SRP maintenance, LPO, electrical consumption for SRP period and without SRP maintenance and tubing pump recondition but including the PCP rental for PCP period. The last one was profit, which was the subtraction of revenue and total cost. The factors that were contributing to economic calculation is simplified: A : Revenue (USD) B : Oil Gain (BOPD) C : Oil Price (USD/BOPD) D1 : Total Cost (USD) SRP Period D2 : Total Cost (USD) PCP Period E : Well Service Cost (USD) F : Tubing Pump Recondition Cost (USD) G : SRP Maintenance Cost H : LPO (USD) I : Electrical Consumption Cost (USD) J : PCP Rent Cost (USD) K1 : Profit (USD) SRP Period K2 : Profit (USD) PCP Period The

economic calculation of this study consist of: A = B x C D1 = E + F + G + H + I D2 = E + H + I + J K1 = A – D1 K2 = A – D2 The revenue, total cost, and profit is compared for each trial wells between the SRP usage and PCP trial period. The detail of economic calculation for each well is described below. The economic diagram can be seen in Figure 8. Batang 22 and Batang 32: During SRP period, the total cost for these trial wells outweigh the revenue so the loss were USD 19.935 for Batang 22 and USD 17,558 for Batang 32. Meanwhile, after changing to PCP, the revenue was far greater than the total cost so the profit were USD 217,307 for Batang 22 and USD 80,775 for Batang 32. Batang 43 and Batang 72: While in SRP phase, the total revenue for Batang 43 and Batang 72 were greater than the total cost so the profit were USD 45,515 for Batang 43 and USD 1,015,815 for Batang 72. After converting to PCP, the revenue for these wells were significantly bigger than the total cost so the profit were USD 544,234 for Batang 43 and USD 1,754,716 for Batang 72. Overall, the profit for all trial wells in SRP phase was 1,023,837 USD while after changing to PCP was 2,597,032 USD. CONCLUSION This PCP trial in Batang field concludes that: 1. The oil production has proven to be increased by average of 142 BOPD after PCP trial period. Moreover, Batang 72 oil production increased approximately three times higher after converting to PCP. 2. Sand problem has been effectively reduced from 11 to five for all trial wells. Additionally, Batang 22, Batang 32, and Batang 43 also successfully reproduced again after having idle period. 3. Power consumption was significantly reduced by 79% after the utilization of VFD so the power usage could be optimized as per operational requirements. 4. Economically, the total profit in PCP period from all of the trial wells was 2,597,032 USD, which were far greater than the profit while using SRP, which was 1,023,837 USD. 5. PCP is considered suitable as artificial lift method to be used in Batang field based on the oil recovery, sand control ability, power consumption, and economic assessment.

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REFERENCES Alnaqi, Y., 2014, Comparison Between AMPCP and SRP In a Shaly-Sand Reservoir in Terms of Sand Production, SPE-172910-MS. Guo, B., Lyons, W.C., Ghalambor, A., 2007, Petroleum Production Engineering, p. 161-233. Wu, B., Li, X., 2010, The Special Successful PCP Applications in Heavy Oilfield, SPE 136817. Batang 22 Batang 32 Batang 43 Batang 72 Pump Depth 375 ft 324 ft 397 ft 390 ft Mid Perfs 400 ft 365 ft 439 ft 399 ft PBTD 422 ft 530 ft 447 ft 462 ft TD 700 ft 700 ft 600 ft 679 ft Casing 7", 23 lb/ft 7", 23 lb/ft 7", 23 lb/ft 7", 23 lb/ft Tubing 3 1/2", 9.3 lb/ft 3 1/2", 9.3 lb/ft 3 1/2", 9.3 lb/ft 3 1/2", 9.3 lb/ft Rod String 7/8" HS 7/8" HS 7/8" HS 7/8" HS Rod Coupling 7/8" Slim Hole 7/8" Slim Hole 7/8" Slim Hole 7/8" Slim Hole Drive Head Type Electric Electric Electric Electric Prime Mover Type Electric Electric Electric Electric Table 1 – Completion Detail of the trial wells. From this table, it can be seen that the typical wells in Batang field is shallow well with Total Depth (TD) around 700 ft and pump depth ranging from 300-400 ft. Table 2 – Huff and Puff has been performed nearby trial wells in order to maintain the minimum 90°F well head temperature for all wells in Batang field including the trial wells. Batang 22 Batang 32 Batang 43 Batang 72 Figure 1 - PCP pump diagram for each trial wells. The main differences for each pumps are pump horsepower, target flow rate, and pump setting depth. Pump horsepower and target flowrate were calculated by using Inflow Performance Relationship (IPR) for each trial wells. Figure 2 – Batang 22 production profile. In the observation period, the well was considered idle for 8 months prior to PCP conversion. The production increased averagely from zero BOPD (off well) to 15 BOPD. Well service was reduced from two during SRP phase to one after PCP conversion. Wellhead temperature is maintained at 116°F. Figure 3 – Batang 32 production profile. During monitoring, the well was categorized as idle well for 8 months before converting to PCP. After PCP era the oil production has increased from zero BOPD (off well) to 9 BOPD. Well service has been eliminated from 3 times during SRP period to zero after converting to PCP. Wellhead temperature is maintained at 105°F. Figure 4 - Batang 43 Production Profile. Before utilizing PCP, the well was considered idle for 3 months. After PCP period, the oil

production increased from zero BOPD (off well) to 33 BOPD. Well service is reduced from five times (SRP phase) to 3 times (PCP era). The wellhead temperature is maintained at 119°F. Figure 5 – Batang 72 production profile. After converting to PCP, the average production increased from 30 BOPD (SRP era) to 91 BOPD. Batang 72 is categorized as high potential well. Before PCP era, well service was done once for pull out tubing pump and bail out sand prior changing to PCP and after using PCP, rig less well service was done once for rotor replacement. The wellhead temperature was maintained at 142°F. Figure 6 – Batang field scale production. After changing to PCP, Batang production increased for averagely 142 BOPD from four trial wells. PCP installation successfully reactivated 3 out of 4 wells from idle condition due to severe pump stuck issue. The PCP trial also reduce LPO for the trial wells due to less workover activity. Figure 7 – Power consumption for trial wells were significantly reduced after changing to PCP. This was done through the application of VFD that can adjust the power consumption depends on the operational needs. Power consumption has been reduced for average of 79% for all trial wells. Figure 8 – Economic evaluation diagram for all trial wells. From this chart, Batang 22 and Batang 32 experienced negative profit while using SRP. Meanwhile, Batang 43 and Batang 72 already had profit during SRP period. Later on, after changing to PCP all of the trial wells had significant profit boost. * Pertamina Hulu Energi Siak ** Pertamina Hulu Energi

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