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Production Optimization on High GLR ESP Well Using Combination of Surface Annular Gas Separation and Feedback Mode System – Case Study B-20X

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Abstract. Installing ESP in high GLR wells can be tricky. The objective of gaining more liquid production on the surface can be hindered by high gas interference problems. The large amount of free gas ingested into the pump must be mitigated to make sure the pump operates at an optimum condition, hence sustaining the liquid production and prolonging the runlife of the ESP.

Several high GLR wells have been producing using ESP in Bunyu Field, with some of them facing gas interference problem. The common approach to mitigate this problem is by flaring annular gas and applying VSD logic (Intake Pressure or Ampere Feedback Mode) at a certain value. However, there was special case for some wells with very high GLR and low productivity index in Bunyu Field. The annular gas could not be flared due to frequent liquid carryover from the annulus and applying feedback mode alone could not solve this issue.

Further effort and trial were made at well B-20X by installing a surface separation equipment to separate the annular gas from liquid before entering the flare line. With this additional equipment, the annular gas was flared safely and liquid carryover from the annulus could be collected into a tank-on-site.

Shortly after the installation of surface separation equipment combined with pump intake pressure (PIP) feedback mode, the downhole parameters (PIP, Motor Current, and Motor Load) stabilized. The resulting liquid production from the well test was also increasing and becoming more stable.

Keyword(s): Production Optimization; Electrical Submersible Pump; High Gas Interference; Feedback Mode System, Surface Separation Equipment.

1 Introduction

Bunyu Field is one of the working areas operated by PT. Pertamina Hulu Indonesia Zona 10. It is located in Bunyu Island, North Kalimantan. It has a long history dated back to 1901 when the field was first discovered and operated by Bataafsche Petroleum Maatschappij (BPM). Since then, Bunyu Field has been operated by different operators with peak production of 10,000 BOPD came in 1959 under PERMINDO. Nowadays, Bunyu Field produced 4,200 BOPD from 60 active wells. Currently, 14 wells are producing 1350 BOPD, one-third of the total field production, using ESP as its artificial lift.

There are two main reasons for utilizing ESP, firstly, to gross up liquid production from high water cut wells to gain more oil, and secondly, to lift liquid in wells producing from low pressure/ productivity index reservoir. Gas lift, as the main artificial lift in Bunyu Field, usually no longer efficient for the latter wells because the surface injection pressure limitation. Reservoir layers deeper than 2000 meters, which are considered as deep zone reservoir, commonly need ESP to lift liquid to surface. The deep zone reservoir shape is mostly limited, thinly interbedded sand-shale and having solution gas drive as its drive mechanism. As a result, free gas production increases significantly when the reservoir pressure declines to below bubble point pressure. Thus, ESP installation in those wells is expected to face gas interference problem.

2 Problem Statement

Fourteen wells in Bunyu Field have been producing with ESP. Five of them are installed in deep zone reservoir group. Typical challenges of ESP utilization on these wells are gas interference problem, due to high GLR in the wells, and low productivity index from the reservoir, as listed on table 1. ESP operates at the highest efficiency when it is pumping 100% liquid. It means that the more gas is ingested into the pump, the ESP will be less efficient. At worse condition, gas interference could lead to a gas lock problem which further decreases oil production. A gas handler or multiphase pump is used when installing ESP in high GLR wells to mitigate gas interference and gas lock problem. Theoretically, gas handler can handle up to 60-70% free gas entering the pump.

Table 1. ESP installed in wells producing from deep zone reservoir.

Well	**Layer**	**Depth** (m)	**Pb** (psia)	**PIP** (psia)	**GLR** (SCF/STB)
B-17X	Commingle X & Z group	2330 – 2337.5 2370.5 – 2454	2073	80	2400
B-20X	Z-10	2305 – 2308	1533	80	3800
B-19X	Z-20	2329 – 2335	1600	560	1900
B-14X	Commingle X & Y group	2190 – 2192 2315 – 2351	2075	294	1550
B-18X	BB-10	2600 – 2604	1840	618	1850

To address the low productivity index issue, the pump intake pressure (PIP) feedback mode system is applied. It can maintain PIP at a certain value to ensure the pump intake is always submerged by the liquid. Additional method to stabilize production from such wells is by venting/flaring the annular gas to the atmosphere. Those methods are proven to be efficient for sustaining production and prolonging the ESP runlife. However, some wells have liquid carryover issue which requires further attention. The liquid carryover issue creates a major concern to the environment, yet without releasing the gas to the atmosphere, oil production will not be stable.

3 Methodology

Basic idea to mitigate gas interference problem in low productivity index wells is to maintain the liquid level at which the pump is submerged by the liquid and releasing the annular gas from the wells. A surface separation equipment is installed to address the liquid carryover issue.

3.1 Feedback Mode System

Feedback mode system is a control system feature equipped within a specific ESP motor controller. It uses the Proportional, Integral, Derivative (PID) algorithm which provides continuous feedback to control motor speed to achieve a target value. During operation, the Variable Speed Drive (VSD) output frequency will fluctuate as per input settings. Input parameters which can be set as a target value are Pump Intake Pressure (PIP), Motor Current (Im), and DM Temperature. Other variables that can be set to fine tune the feedback mode are the step size/proportional ratio, step interval/integral gain, minimum – maximum frequency, and setpoint error tolerance. Therefore, intake pressure – feedback mode is an essential method to keep the liquid level above the pump intake.

3.2 Surface Annular Gas Separation Equipment

Liquid carryover has been a major issue in several high GLR wells, including B-20X. The previous method of direct flaring to reduce free gas is unsafe due to the possibility of burned liquid carryover. A simple and efficient solution to mitigate the issue on the surface is by using a gas-liquid separation equipment. A set of equipment consisting of a 2-phase low pressure separator and tank-on-site (TOS) is installed and tied-in to the well annulus. Figure 1 shows the schematic of the separation equipment.

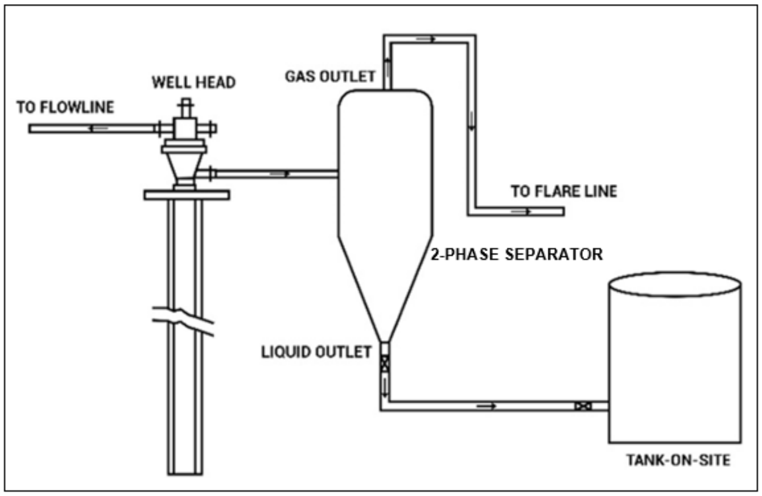

Figure 1. Surface annular gas separation equipment diagram

The gas-liquid flow from well annulus will be diverted to the separator inlet. There will be a separation process between gas phase and liquid phase within the separator using inlet diverter and gravity principle. The gas will come out from the upper outlet and flow directly to the flare pit. If there is any liquid phase, it will come out from the lower outlet and will be collected safely in the tank-on-site.

4 Case Study

Well B-20X is producing from layer Z-10 of deep zone reservoir with solution gas drive as its main driving mechanism. The reservoir pressure has depleted to below bubble point pressure. Therefore, the GLR from the reservoir, 3800 SCF/STB, is considered very high. A severe gas interference problem occurred at well B-20X despite the use of multiphase pump. In addition to gas interference problem, B-20X is also having a low productivity index reservoir.

The low productivity index condition was identified shortly after ESP first started up, with pump intake pressure (PIP) value dropped to below 80 psi, triggering low PIP trip alarm. PIP feedback mode was used to maintain PIP at 80 psi to keep the liquid level above pump intake. However, excessive amount of trapped annular gas has made the surface casing pressure increased. The gas column would push down the liquid level in the wellbore and create the possibility of gas interference and gas lock problem. To overcome the gas interference problem, releasing annular gas to the flare pit had been executed and was successful as indicated from continuous liquid flow on the surface, giving average oil production of 100 BOPD.

After several days of continuous venting/flaring, there was liquid carryover from well annulus that flowed to the flare pit. To prevent more liquid carryover, the casing valve was closed, thus creating accumulation of free gas in the well annulus. Figure 2 shows the downhole ESP parameter after casing valve was closed. At this condition, oil production decreased to only 40-50 BOPD and it could reduce ESP runlife in the long term due to the possibility of gas lock and pump off problems.

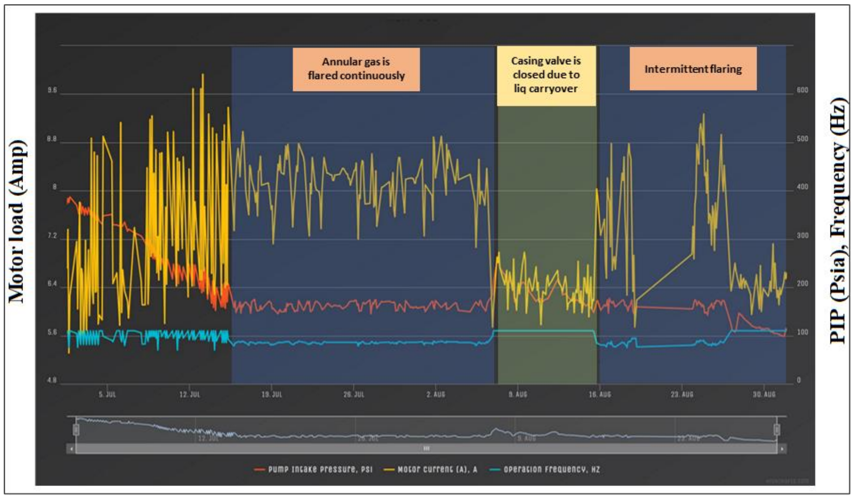

Figure 2. Downhole parameter of ESP B-20X

To address the challenges in well B-20X, the combination of PIP feedback mode and surface annular gas separation equipment was implemented.

5 Result and Discussion

The implementation of PIP feedback mode and surface annular gas separation system successfully sustains the production of well B-20X. Adding a simple separation equipment to the existing well is proven to significantly minimize gas interference and gas lock problem. From figure 3, it is understood that the downhole ESP parameters (PIP and motor current) are stabilized, thus creating a more stable ESP operation.

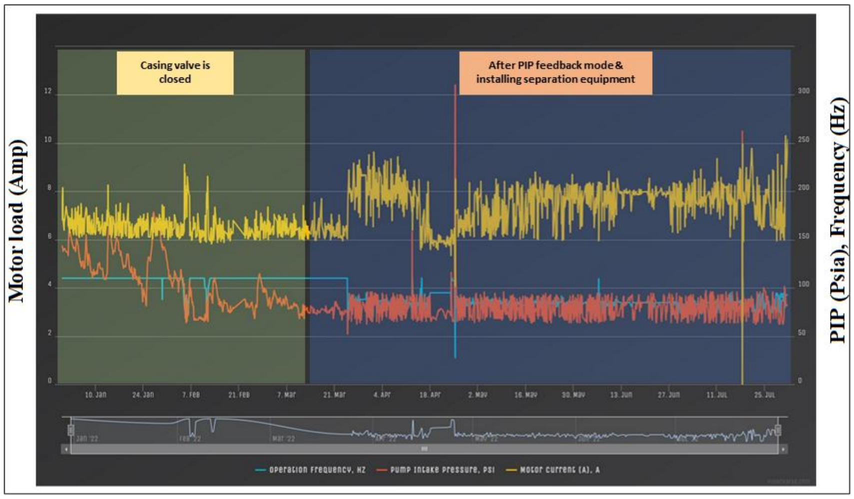

Figure 3. Downhole parameter before and after installing surface separation equipment

By releasing trapped gas from the wellbore, the surface casing pressure decreased to 0 psi. And without any backpressure from the free gas, liquid level will subsequently rise. As a consequence, gas lock and pump off problems can be overcome. Furthermore, oil production is also increased to nearly 100% from an average of 40 BOPD to 80-100 BOPD as shown in figure 4.

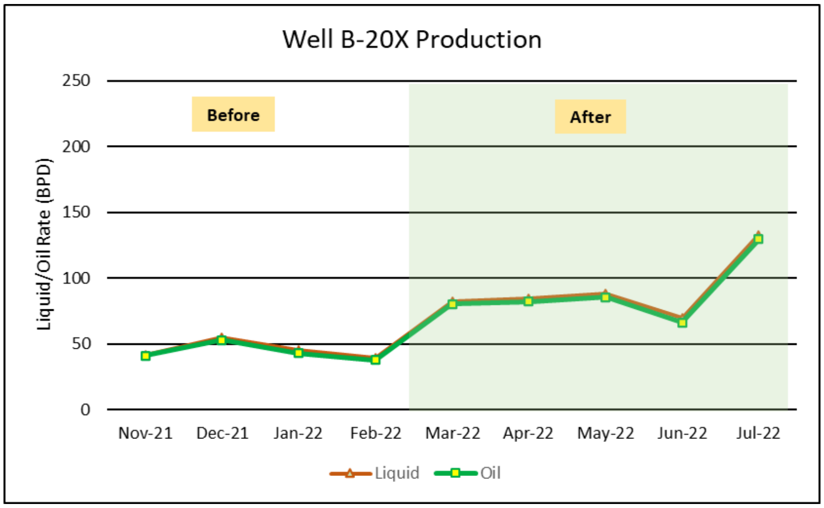

Figure 4. Well B-20X production

6 Conclusion

The conclusions of the paper are:

1. Typical challenges on ESP operations in deep zone reservoir group in Bunyu Field are low productivity index and gas interference problem due to high GLR.
2. PIP feedback mode is used to keep liquid level above pump intake and venting/flaring annular gas is used to stabilize downhole parameter, avoiding gas interference problem.
3. A surface separation equipment is installed in well with liquid carryover issue to eliminate the possibility of liquid carryover.
4. The combination of surface annular gas separation and PIP feedback mode system is proven to improve ESP operations and sustain oil production from well B-20X.

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