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Improving Well Performance with Bottom Feeder Intake on Electric Subsmersible Pump in Gassy Wells

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Improving Well Performance with Bottom Feeder Intake on Electric Submersible Pump in Gassy Wells

Clarissa Tyas Puspita[1], Mery Luciawaty[1]
Pertamina Hulu Energi – Offshore North West Java[1]

Abstract

Oz is an offshore oil field with Electric Submersible Pump (ESP) as the main artificial lift system. Gassy well condition become a key challenge in this field as some ESP wells trip due to pump gas locking, and this is leading to production deferment and ESP failures. Several applications such as gas separator, gas handler, and multiphase pump have been installed on the ESP system, but gas locking is still occurring in some wells. This paper will present a new approach at Oz field to improve well performance by implementing bottom feeder intake application on electric submersible pumps in gassy well.

To analyze this gas locking problem, well production simulations were performed and found out that flow pattern below the ESP completion is slugging at some well conditions. As in slugging flow pattern the liquid hold up in the annulus may reduce to 30%, thus when the slug reach pump intake a large amount of gas volume will enter the pump and create gas locking. In this condition, gas separator or gas handler would not able to prevent gas locking to happen on the pump. Bottom Feeder Intake (BFI) was proposed as a solution in handling gas when slug flow pattern occur in ESP wells.

Electric submersible pump with bottom feeder intake were successfully installed in several wells in 2016. The bottom feeder intake was combined with gas separator and still operating since then. This application significantly minimizes gas locking problem, reduces deferred production, and gives opportunity to increase production of ESP wells.

Through well production simulation and analyzing the effect of fluid flow pattern below ESP completion to pump gas locking symptom, bottom feeder intake has been chosen as an effective solution minimize gas locking in gassy well.

Keywords: *ESP, Gassy Well, Bottom Feeder Intake*

1. Introduction

The ONWJ area is located on the north Coast of Java Island in Indonesia. The ONWJ Field is operated by PT. Pertamina Hulu Energi ONWJ since 2009. The area consists of several fields and has been producing since 1971 with more than 700 wells and 150 production platform.

Oz Field is located in the West Asset of ONWJ Area and 80 km from north Jakarta. It was discovered in 1974 by ZZZ-1 wildcat well and start produced in December 1986 with peak production 24,000 BOPD in 1987. The field consists of 69 wells and 8 platforms. Currently, Oz field produces 3,000 BOPD from 4 platforms with 24 active wells. Electric Submersible Pump (ESP) was selected as the main artificial lift system in Oz Field.

Gassy well condition become a challenge in this field as some ESP wells trip due to pump gas locking, and this is leading to production deferment and ESP failures. Several applications such as gas separator, gas handler, and multiphase pump have been installed on the ESP system, but gas locking is still occurring in some wells. Such systems many times could not handle the gas locking on the ESP.

2. Basic Theory

The electrical submersible pump (ESP) is widely used as an artificial lift in petroleum industry. ESP system is downhole equipment which converting kinetic energy to hydraulic pressure head, has improved significantly since invented in 1910s. ESPs are applicable in deep and deviated wells. The size of the pump defines the maximum capacity of ESP to pump the fluid rate. The rotation of ESP depends on the motor speed (frequency) which can be adjusted by surface controller - variable speed drives. The highest efficiency of ESP is when pumping liquid only (Bagci *et al*, 2010).

Improved ESP performance and runlife, generally achieved at condition with lower free gas volumes. Ideal conditions are when gas volume factor is below 20% at the base of ESP. Up to 70% of gas volume factor can be handled effectively if special steps and equipments are applied in ESP (Romer et al, 2012). Gas volume factor is a complex function of the fluid properties, production rate and reservoir pressure depletion.

Gas volume factor is very related to the evolution of reservoir, which caused the changing of composition produced fluid. Conditions for a multiphase petroleum system is defined with a phase diagram **(see Fig. 1).** The phase diagram illustrates conditions for system as function pressure and temperature.

Typical production scenario is starting with high fluid rates while handling some gas. Over period of time, production rate falls and gas production rises which created a different pattern of flow regimes in well bore.

Flow regimes are the patterns of flow which depending on variety of operating condition, such as flow rates, fluid properties, geometry of well bore and pressure differentials. Prediction of flow regime can be difficult and several methods are used including analytical, empirical and numerical solutions (Li, 2007).

Multiphase flow in the horizontal well are classified as dispersed bubble, annular, stratified, slug and elongated **(see Fig. 2).**

Based on the analysis of well observation and well production simulation, intermittent flow of ESP wells caused by the type of slug flow or elongated bubble flow.

Slug flow is an intermittent flow pattern, characterized by an alternating flow of gas and liquid. The liquid slugs, which fill the entire cross section of the well, are followed by gas pockets. Gas bubbles travel at the top of the horizontal section of well bore due to low density of the gas bubbles. Which, elongated bubble flow similar to the flow pattern of slug flow, but the size of the bubbles are generally smaller.

3. Methodology

Basic principle to find the effective solution for ESP gas locking problem in Oz Field, is understanding the reservoir characterizations by performing well production simulation. Oz field which has limestone Baturaja formation as the main reservoir, is located in the highest structure. It has possibility hydrocarbon source from Seribu & Sunda Trough. Heavy oil (20 API) and high viscosity (40 cP) are the oil characteristics of Baturaja Formation. This formation has porosity ranges from 30% to 35% and permeability from 500 to 1000. The average reservoir thickness is 10 – 25 ft.

3.1 Well Production Simulation

To analyze this gas locking problem, well production simulations were performed. The value of free gas at the pump intake (calculated from simulation runs using Prosper application) and produced GOR (measured through in-field production tests). Based on simulations, found out that flow pattern below the ESP completion is slugging at high deviated and horizontal wells. As in slugging flow pattern the liquid hold up in the annulus may reduce to 30%, thus when the slug reach pump intake a large amount of gas volume will enter the pump and create gas locking.

3.2 Bottom Feeder Intake ESP Design & Installation

Through well observation and well production simulations, develop the analysis of the effect of slugging flow pattern below ESP completion to pump. And, bottom feeder intake has been chosen as an effective solution to minimize gas locking in gassy well.

The design of Bottom Feeder Intake (BFI) is quite simple. BFI is an intake which has self-orienting bottom suction **(see Fig. 3).** It is ideal for increasing the natural gas separation in high deviated or horizontal well.

The intake has an eccentric weighted outer sleeve that rotates by its own weight during installation in well, positioning the inlet ports at the lower side of the casing annulus. Gas being lighter, by passed the inlet ports, while the heavier fluids enter the pump - gas separator or gas handler **(see Fig. 4).** This new intake is installed on ESP replacing the standard intake.

4. Case Study

Some Oz ESP wells experienced ESP trip due to pump gas locking. And, this phenomenon is leading to production deferment and ESP failures.

Based on well production simulations, found out that flow pattern below the ESP completion is slugging at high deviated and horizontal wells.

Gas slugs of extended durations can cause liquids to be unloaded conditions erratically. This sporadic production regime makes pumps lose prime and cycle on and off. Under these conditions, several applications such as gas separator, gas handler, and multiphase pump, which are normally used to prevent gas locking, are rendered ineffective.

With increased gas fraction at pump intake, it causes ESP operation unstable. That shows itself as a change of liquid and gas flow rates at the surface during the period of time. And, based on ESP downhole sensor, gas lock symptoms was seen as the fluctuations of ESP parameters **(see Fig. 5).**

Gas locking which ultimately causes pump cavitation, with less fluid through pump, it will cause production deferment as shown in production well test plot.

5. Result and Discussion

The result of the following case study regarding the application of Bottom Feeder Intake system were successfully installed in Well-1, Well-2 and Well-3 in Oz field. The

BFI was combined with gas separator and still operating since then. This application significantly minimizes gas locking problem, reduces deferred production, and gives opportunity to increase production of ESP wells. Based on ESP downHole sensor, gas lock symptom significantly decrease since the BFI installation **(see Fig. 6).**

Based on production well test **(see Fig. 7)**, production increament were significant enough that total production is increase ~625% of the original production rate **(see Fig. 8 and Table. 1)**, which shows a significant improvement in generated profit due to this new method. This successful new method was planned to be applied on other development wells in Oz Field.

6. Conclusion

Based on the post ESP installation evaluation, the following conclusions are :

1. Slugging flow pattern may occur at below ESP completion, especially in-high deviated and horizontal wells.
2. Bottom feeder intake (BFI) system was successfully minimized the gas lock symptoms on 3 wells.
3. Bottom Feeder Intake also successful to reduce the number of ESP trip/underload, and operational interventions (start-stop ESP), which resulting in ESP runlife improvement.
4. Bottom Feeder Intake proven to improve natural gas separation efficiency on ESP.
5. Bottom Feeder Intake is easy to implement on any other gassy ESP wells due to its simple installation.

7. Recommendation

Bottom Feeder Intake application is the most effective solution to minimize gas locking in gassy ESP wells. Especially, gas locking which caused by slugging flow pattern below ESP completion at high deviated and horizontal wells.

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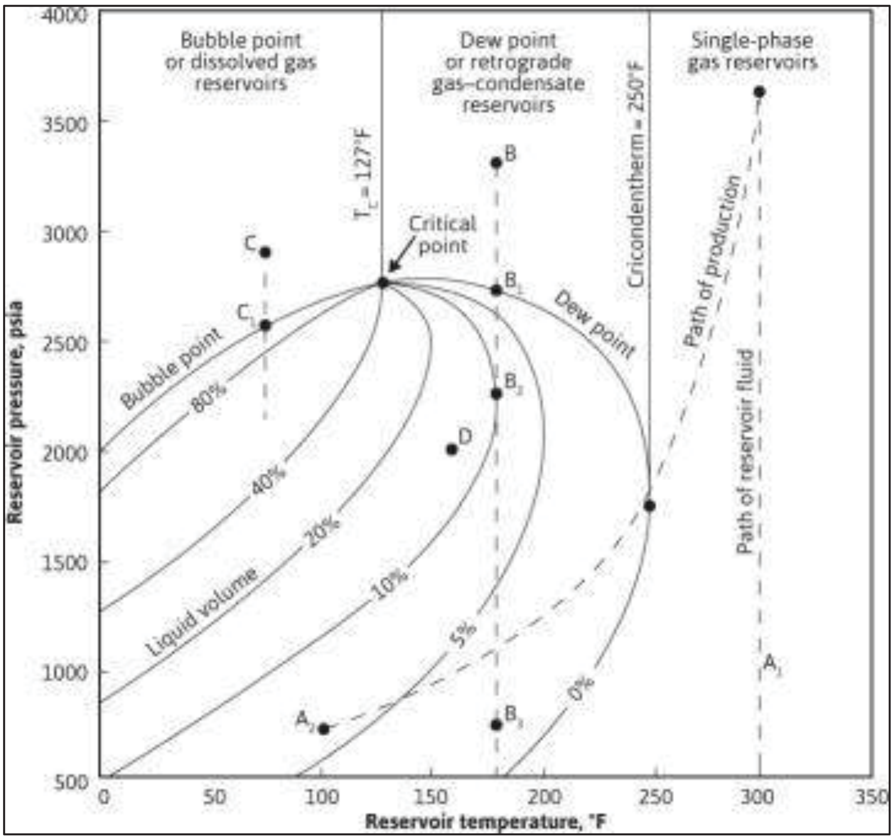

Figure 1. Hydrocarbon Phase Diagram

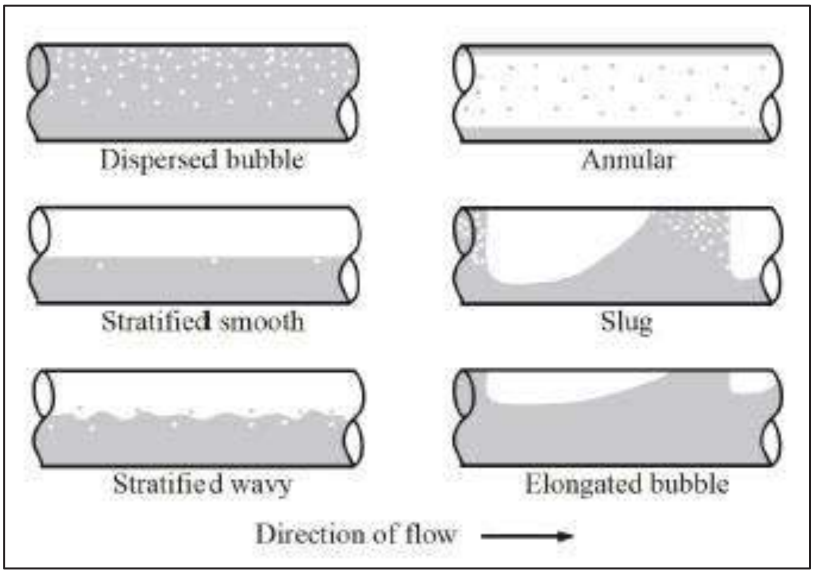

Figure 2. Flow Regime in Horizontal Section

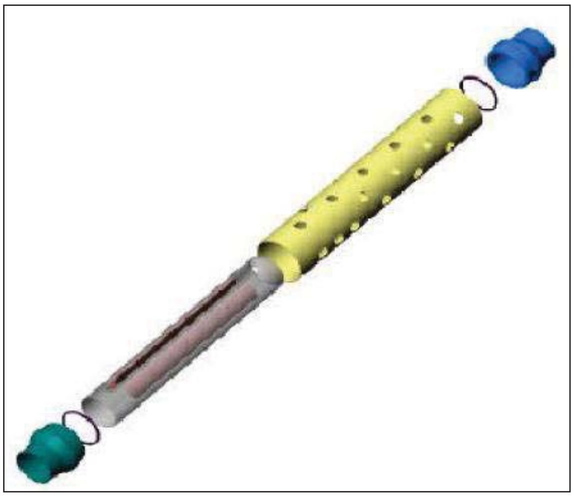

Figure 3. Bottom Feeder Intake

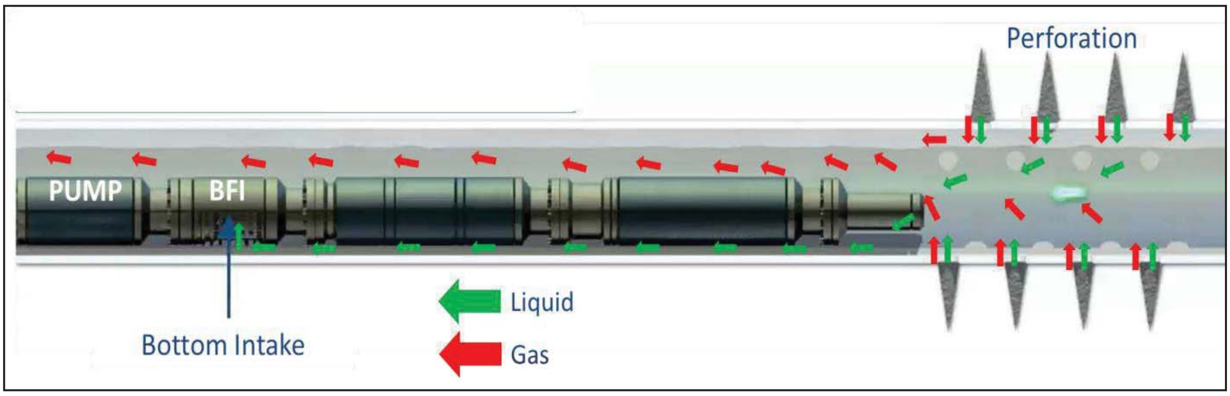

Figure 4. Flow Pattern at Bottom Feeder Intake

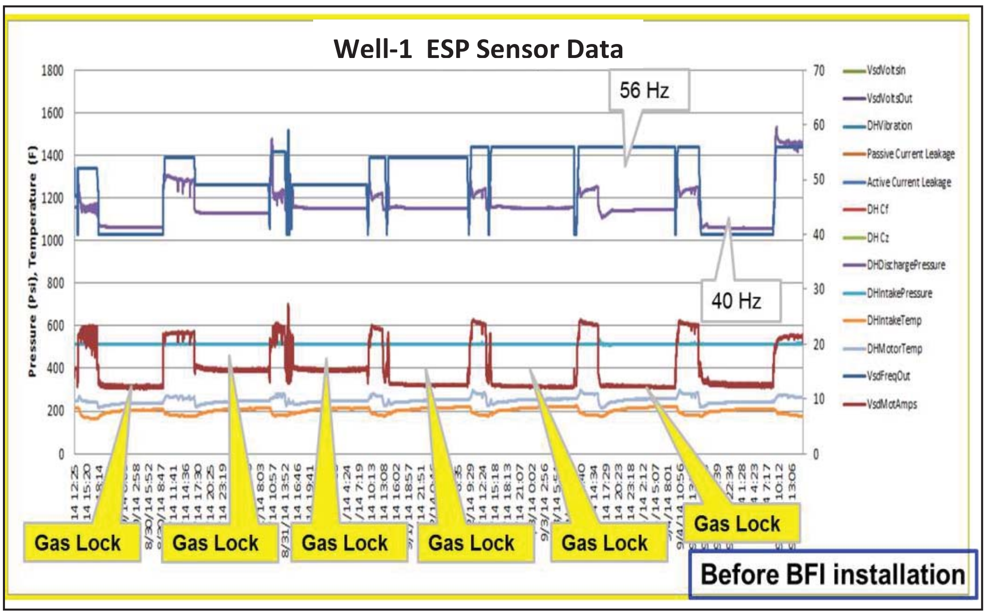

Figure 5. ESP Downhole Parameter (Before BFI Installation)

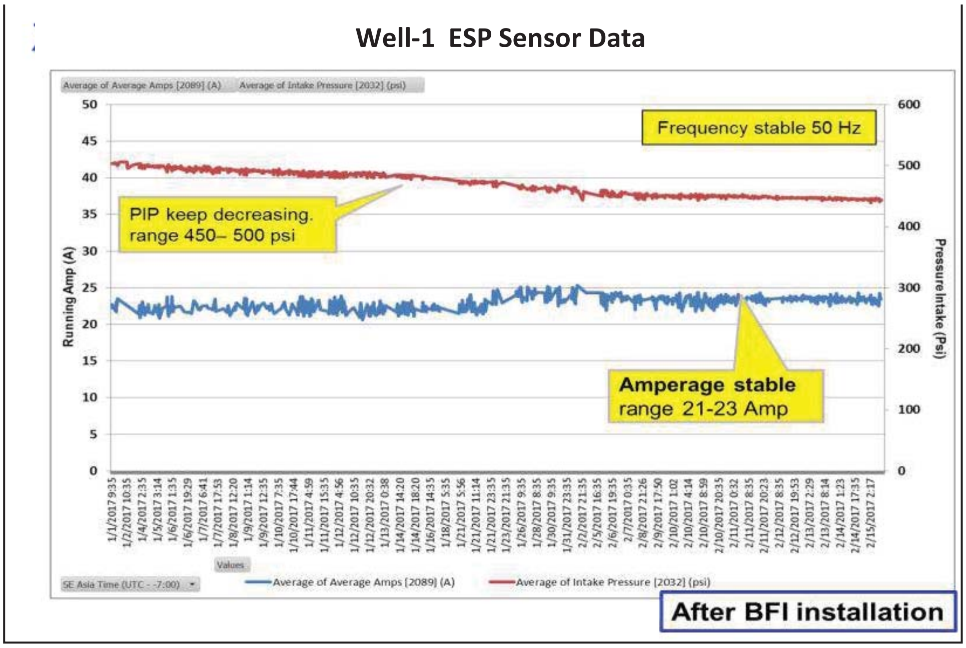

Figure 6. ESP Downhole Parameter (After BFI Installation)

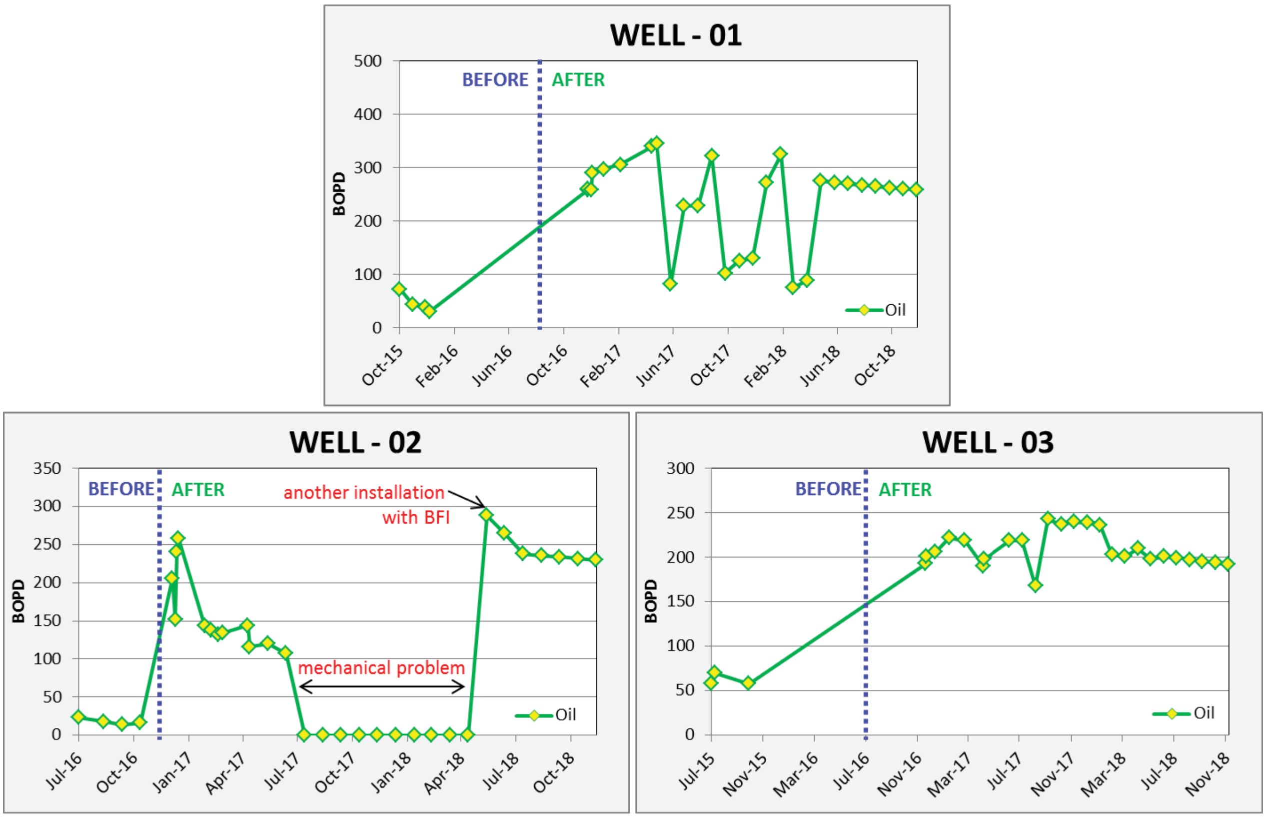

Figure 7. Production Plot

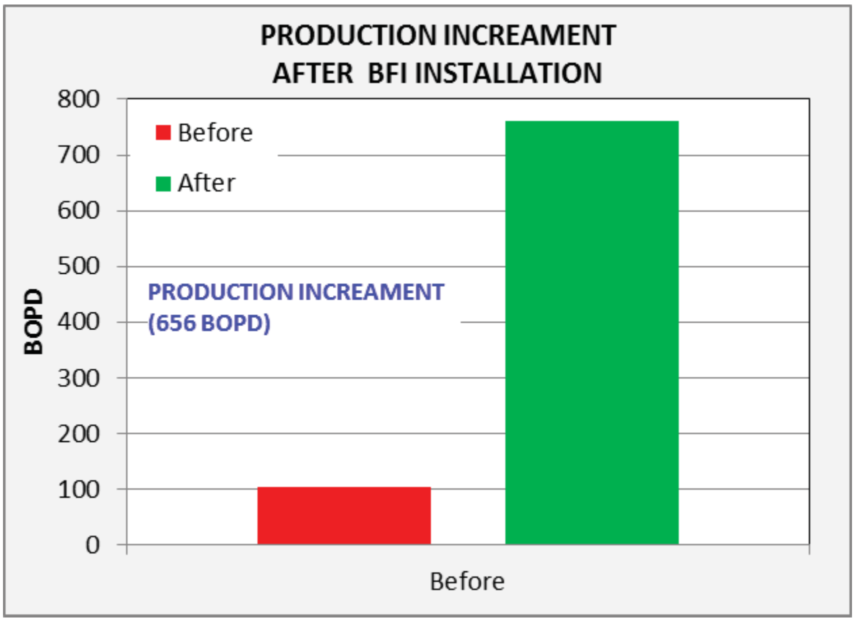

Figure 8. Production Increament after BFI Installation

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Table 1. Production Increament after BFI Installation

	Well	Last Rate BOPD (Before Installation)	Initial Rate BOPD (After Installation)
1	Well - 01	31	297
2	Well - 02	16	258
3	Well - 03	58	206
TOTAL		**105**	**761**