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Research Article

Auto Gas Lift-The Intelligent Well Solution to Increase Productivity

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Abstract

As the global demand for energy keeps growing, the demand for oil and gas will keep mounting. Billions of dollars are being spent by oil and gas industries to set up the infrastructures of smart field. Managing these fields involves combined methods and knowledge for unmanned and independent handling of these field an enough number of synchronized data is gathered and monitored from wells for smooth and uninterrupted operation. Among all forms of artificial lift, the most common used is automatic gas lift, which is mostly used for offshore wells. The reason for its simplicity and relative use is its downhole flexibility, simplicity, reliability, and capability to operate over a widespread range of flow rates with restricted well head space. Implying the Automatic Gas lift (AGL) technique can cut the operational cost and increases the "Net Present Value" (NPV) by maximizing recovery from a field.

In this study, GAP models were being made for DN horizontal, DI Vertical, Non-Contagious (NC), and AGL. The models made were used to predict cumulative oil production, gas production, water production, and pressure drop. After all the predictions were made comparative study was done in order to understand the trends. The results demonstrate substantial increase in oil recovery using Auto Gas Lift in the field through vertical wells 1,2 and 3 which otherwise is quite low in do-nothing case. Moreover, it has been observed that Auto Gas Lift provides higher recovery compared to vertical wells. Hence, fewer number of horizontal wells can be bored in the field to increase revenues and ultimate increase in efficiency of the reserves.

Keywords: *Automatic gas lift, GAP, Oil, recovery.*

1. Introduction

Once the oil is first found in the reservoir, natural forces surround the oil and causes the high pressure. A hole is drilled in a well with an opening at lower pressure then reservoir causes the reservoir fluids to discharge due to pressure difference(Abreu *et al*., 2015). The force that drives the fluid to travel is compression of that fluids stored in a particular reservoir(Glandt, 2003). The difference in pressure between production facilities and reservoir causes the oil to move towards the surface (Vasper and Operations, 2008).

IWS (Intelligent well system) systems have installed throughout the world. Estimation, Justifications have been made to implement IWS technology based on various factors. These ranged from increased overall production, efficient recovery, reducing or eradicating intrusion, and to improve the overall performance of a reservoir (Gimre, 2012). A "smart" (or intelligent) well system is a non-conventional well containing smart completions which contain series of sensors and valves, connected on tubes used for production tubing and also allowing constant monitoring and modification of rates of pressure and fluid flow in a reservoir (Peringod *et al*., 2011).

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It also provides flexible control of each segment within a multidimensional well self-sufficiently. In horizontal well, they transform the bore of well is transformed into a multi branched well, by providing flexible control of each segmented branch. Smart wells are an important element towards advanced well technology. The benefits of smart well have been verified, especially in a industry with multiple reservoirs (Yeten, 2003). The benefits of a single reservoir production are also being under exploration. Because the smart wells are capable of monitoring and controlling the rates of fluid flow and pressures, they also increase the production rate of each controlled branch. Hence, this technology provide new ways of improving the management of a reservoir (Yeten and Jalali, 2001). Along with its numerous advantages, there are also some disadvantages linked with advanced well technology. Drilling and operating these wells carry some risk, mainly due to mechanical failures or incorrect trajectory selection or landing. The uncertainty due to reservoir description further complicates the problem(Zhang, 2018).

Reservoirs pressure declines over time and also the rate of production decreases. The Gas lift technology is used to surge the overall oil and gas production rates and it also restrict the wells from overflowing by dropping hydrostatic head in the fluid column of a well (Al Abdin, 2000). Moreover, these systems are also implied to keep tubing head pressure in limits and reduce the effect of high water cut (Youl and Finley, 2010). The Gas which is being inserted in to the chamber of hydrostatic column decreases the overall pressure and density, letting the well to flow smoothly (Camargo *et al*., 2014). If the volume of gas which is used to the lift the oil is not upheld correctly, the oil which is produced from a well will fall back in the tubing, and a condition is created in the well which is called "loading up." If the gas volume is too high, compression and recovery cost of will become significantly high in comparison to the cost of production (Goh *et al*., 2008). Thus the increasing size of a gas injection orifice will significantly affect the smooth process of the well (Julian *et al*., 2014).

A conventional well is a vertical or a little deviated well. Horizontal and multilateral wells are generally being referred as nonconventional or advanced wells (NCWs). A conventional well is as simple as a horizontal well, we also call it a vertical well bore containing a sidetrack (Durlofsky and Aziz, 2002). The drilling of non-conventional wells is considered as a standard practice nowadays. A single non-conventional well is more cost-efficient than various vertical because more the wells more the cost. These attractive advantages, which lead to more effective reservoir management, are driving oil and gas firms to reconsider fields which previously had marginal economics, such as mature, tight, thin or heavy oil reservoirs. In comparison with the conventional wells, Non-conventional wells provide better exposure to the reservoir with fewer number of wells, therefore increasing the overall production and injection strategies (Elldakli, 2015).

Gas lift technology is a suitable technology and it is successfully implied to the wells having low production to increase their production and efficiency (Julian *et al*., 2014). The oil wells suffer due to increasing water cut over the life of the wells which increase the hydrostatic load and eventually self-kill the wells (Botto *et al*., 1996). Conventional gas lift drive gas into the downward section from the surface which needs a large investment in terms of compressors, pipelines, and various other equipment and staff (Kalateh *et al*., 2016).

The application of artificial lift eradicates need for surface structure and other operational expenditures by using in situ gas cap gas as free energy is called Natural, in situ or Auto Gas Lift(Ezzine, 2013).

Auto Gas Lift (AGL) is a method which uses gas from a non-associated gas (NAG) reservoir or associated gas (AG) in coordination with the gas cap in a skillful manner to increase the production from an oil reservoir. The main function of this gas is to decrease the hydrostatic head of the fluid produced, that will allow the lighter fluid to come up at the surface at much higher rate. The injection of gas into tubing is controlled by an inflow control valve (ICV). ICV can be used to adjust the required amount of gas inserted in the tubing on the basis of conditions of an oil reservoir and its capability to handle small particles and water which are produced during the extraction of fluid (Guest). The main advantages of such a system includes reduction in CAPEX and OPEX, stability in production and wells start faster after closure and delayed gas lift investment improving project economics.

Accelerated schedule compared with lift solutions requiring significant surface engineering scope

When the complexity of a reservoir increases the need of Intelligent Well system grow because it provides a simple and cost-efficient approach for extraction. These wells have capability to limit or eliminate undesirable fluid production (gas or water) form zones of various reservoirs in a working well. Water or gas distribution within a injection well or in between the layers, sections, or reservoir, is controlled via this intelligent well technology. Implying intelligent well system various improvement are found; first identified improvement is much greater efficacy in terms of resource utilization, workflow and equipment (Konopczynski and Ajayi, 2007). Example of resource efficacy are freedom of a engineer dedicated to the reservoir in his office, automation technician within field, for monitoring and controlling the well operation. The second benefit include impact on the entire reservoir(Liu *et al*., 2010). It can be achieved either by accelerating recovery of hydrocarbons or by improving the overall resource recovery. Next benefit is safety and reliability of system, wherever there is intervention of human within a system, safe operation is always questioned in comparision intelligent well system provide much more safety and reliability (NadriPari *et al*., 2014). Moreover, by reducing the no. of components will help installation of system much easier and more cost efficient. Additionally, by implementing intelligence will allow decision making easy, reduce response time (Ng *et al*., 2015). The final task is to protect assets of a reservoir, the hydrocarbons which ae recoverable are increasing the efficiency of the well. So, by implementing intelligent well system we are actually reducing the complexity, with much better performance in the production and cost-efficient technology with financial benefits(Parekh *et al*., 2013).

Conventional gas lift systems require a significant investment for compressor, pipelines, and other equipment. Whereas the payback is low and the fields are not potentially utilized in terms of oil and gas extraction. numerous studies have been done to increase the extraction of oil and gas from a field. Research and development over the course of time had invented several methods and technologies to improve the efficiency of the field and to increase the economic benefits of a certain field. The application of Auto Gas Lift shows an increase because it eradicates the need for artificial lift network at the surface and operational expenses. This study is performed to see the difference between DN, NC, GI and AGL technology.

2. Methodology

The integrated well model will be built which will be used to adjust variable factors (Water cut, GOR, PI and reservoir pressure) which are likely to vary over the life of the well. The model will help to make oil recovery comparison in do-nothing and auto-gas lift case. In this research a comparative study was performed for Noncontagious, DN horizontal, GI vertical and AGL technology. All the results were estimated by a computer program known as GAP and MBAL. All the resulted were obtained and compiled in excel to see the trens of oil and gas production along with water production and pressure drop. The estimates were used to see which option is the most suitable and economically viable.

2.1 Well Performance by using PROSPER Software

Prosper is a fundamental element in the Integrated Production Model (IPM) as defined by Petroleum Experts, linking to GAP, the production network optimization program for gathering system modeling and MBAL, the reservoir engineering and modeling tool for making fully integrated total system modeling and production forecasting. The objective of this section is to set up prosper model for a gas well, input the PVT values, draw the phase diagram, draw the down hole, construct the IPR, matching the model to a well test and performing the calculation of well performance, gradient transverse, and vertical lift performance curves.

2.2 Production Optimization Using GAP Software.

The optimizer controls production rates using well head chokes, ESP operating frequencies or allocating lift gas to maximize the hydrocarbon production while honoring constraints at the gathering system, well and reservoir levels.

- Allocation of production.
- Predictions (production forecast).

GAP models can run both injections as well production systems at the same time, containing gas, oil, and water that are produced from a well. GAP can also optimize and maximize the oil production.

2.2.1 Production Forecasting

GAP can also be used to calculate the production forecast from a field which includes gas and water injecting systems that are important for pressure constraints of a reservoir. The pressure within a reservoir is obtained by the decline in curve, and material balancing, or the models used for simulation. The system can be optimized and modeled according to the pressure requirements. Nowadays we can run and operate GAP via the network or server technology, that has open field for remote operation of a field for experts.

2.3 Link to MBAL

The performance of a reservoir depends upon production forecasting which is provided by links to the experts of petroleum field under the material balance or MBAL program. To get optimum production and calculation for various variables like pressure, temperature GAP software is being used along with MBAL.

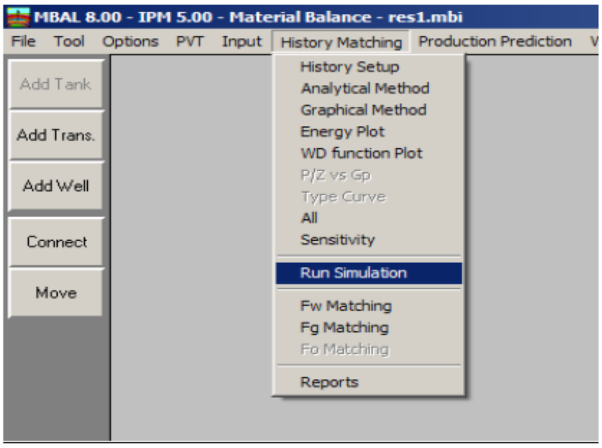


Fig.1 Accessing the Simulation option in MBAL

In case of oil the linear regression uses selected point in analytic method with respect to their weighting. This option is unavailable for multitask cases. The following dialog box will appear when we access this option History Matching | Sensitivity menu.

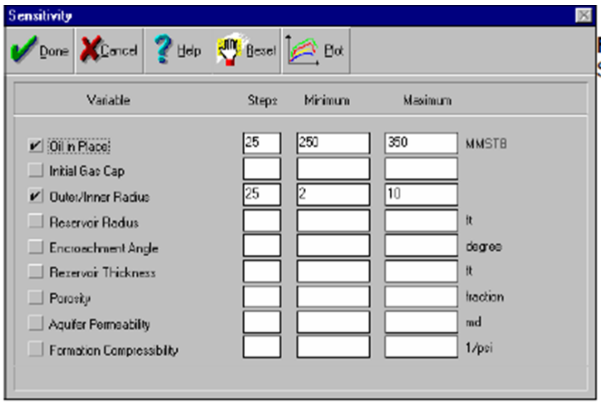


Fig.2 Sensitivity Analysis

The Actual data of experiment was inserted in model. Simulation was performed by the software.

2.4 Link to PROSPER

The performance of well depends upon production forecasting which is provided by link to the experts of petroleum by PROSPER with IPM suite. PROPSER also run-in batch mode with GAP to generate the simulation and curves for performance of well.

2.5 Simulation in MBAL

The dialog box for simulation is used to run a history of production based on models of aquifer that can be further turned into analytical and graphical form. These calculations serve as quality check based on history of matching done. The analytical method uses historical data to predict the production rates by using the data for reservoir pressure. While the simulation method done the opposite of analytical method, the reservoir pressure and historical data is computed on material balance model.

2.6 Smart Well Modeling in GAP

The IPM Suite has been developed over the course of year to model and optimize complicated completions like Intelligent well systems and others. This software was used to predict Oil and gas production along with water within a well. To predict and illustrate the GAP model with actual system several cases were run as part of the real system which are described below.The sketch below is a reference point to all the cases in this case the GAP model was run without any actual data. As shown below the Gas 1B, 2B and 3B are closed. The GAP file for all the cases would include well heads (as shown Well 1B, 2B and 3B), Reservoirs, along with a gas layer.

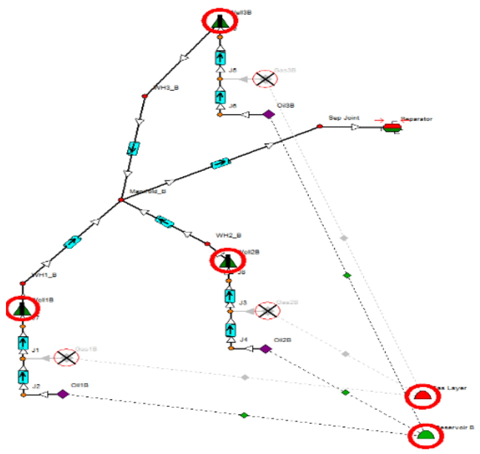


Fig.3 Do Nothing Case

When the AGL will start as shown below the Gas 1B, 2B and 3B are opened. Once AGL starts the system would look like:

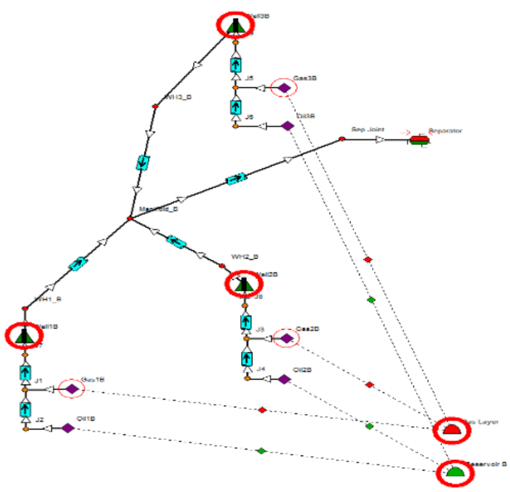


Fig.4 AGL Starts

For the non-contagious case when AGL is off, as shown below the Gas 1B, 2B and 3B are closed.

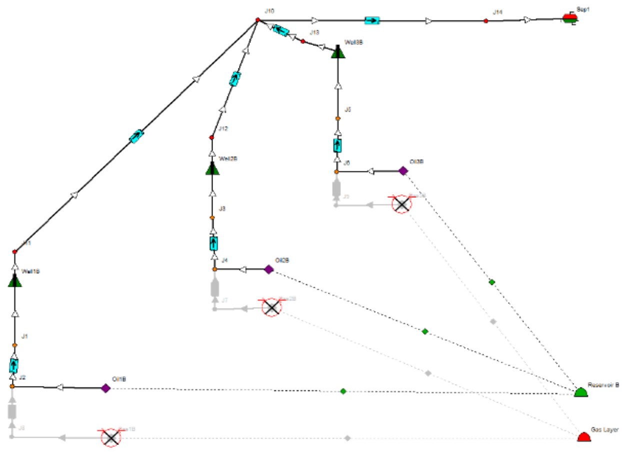


Fig.5 Non-Contagious Case-AGL switched off

For Non-contagious when AGL is switched ON, the valves of Gas 1B, 2B and 3B are opened, as shown in the case below:

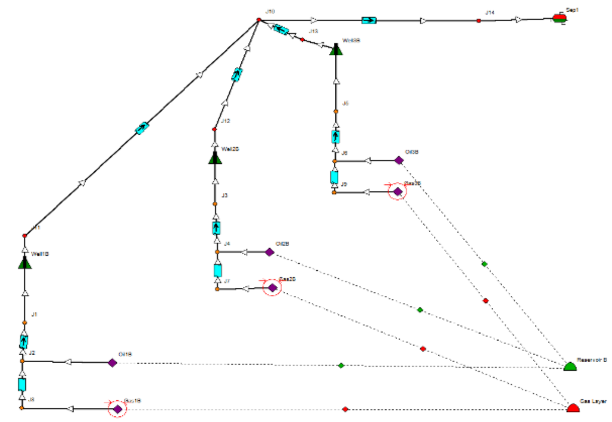


Fig.6 Non-Contagious- AGL switched on

The last case is for Horizontal well with AGL switched off, the valves of Gas 1B, 2B and 3B are opened, as shown in the case below:

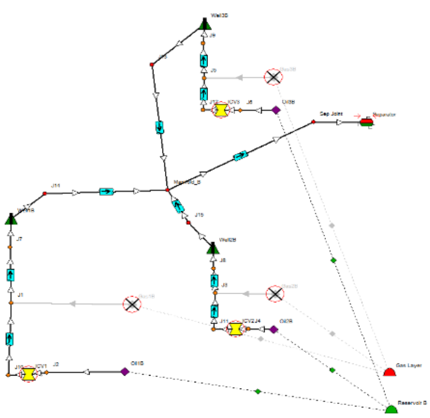


Fig.7 Horizontal well with AGL switched off

The script would be added to the end of each step.

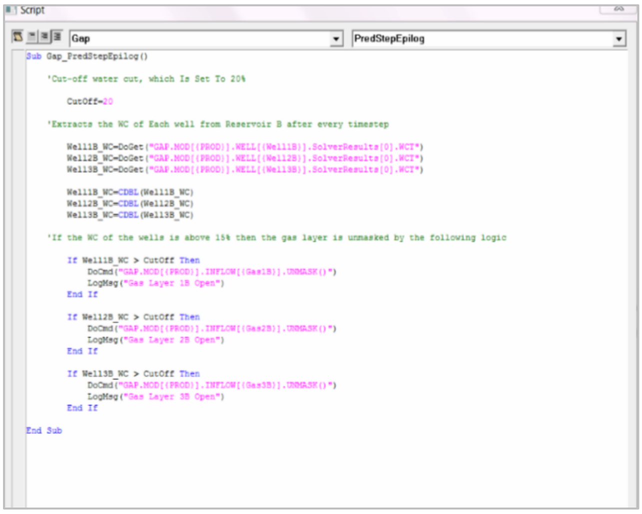


Fig.8 Prediction Script

3. Result and Discussion

3.1 Production results of vertical DN and GI

3.1.1 Oil Production rate of Vertical DN and GI the tables

The Results in Figure 9 clearly Shows that using a Vertical GI Coupling increases the overall oil production in Field.

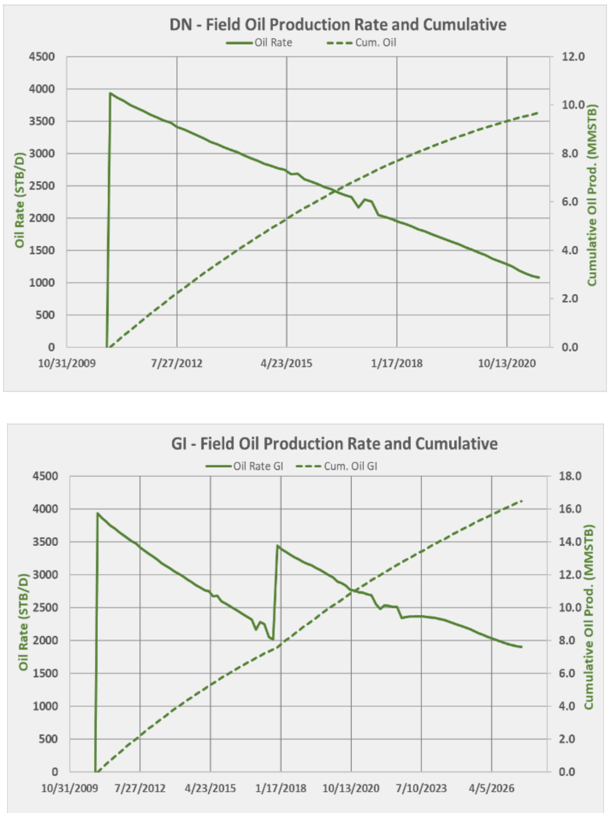


Fig.9 Oil Production Rate of Field

The results indicated that using GI technology more oil was produced in comparison with DN technology. GI technology is a bit costly in comparison to that of DN but the long-term benefits in terms of oil recovery which will affect the overall revenues should not be neglected. Figure 9 represent the oil production rate of a filed, from the figure the oil production of DN-field is less as compared to GI-field. As clearly shown in figure oil production shows a sharp increase after uniformly decreasing whereas using DN oil production keeps on dropping.

3.1.2 Water Production Rate of Vertical DN vs Vertical GI

Results in Figure 10 Shows that when using a Vertical GI Coupling the water production from the field and wells also increased. As the GI technology is more sophisticated in comparison with the DN so the water production rate is also higher.

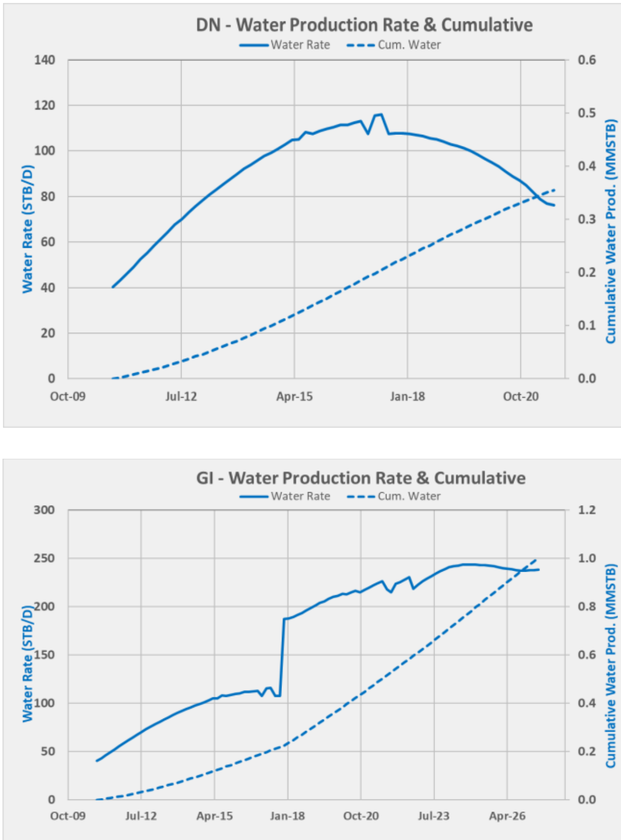


Fig.10 Water Production Rate of Field

3.1.3 Gas Production Rate of Vertical DN vs Vertical GI

The Results in Figure 11 shows that when using a Vertical GI Coupling the overall Gas production from the field and wells increased significantly. This represents the cumulative gas produced in field with vertical DN shows less gas produced while vertical GI has much higher gas production.

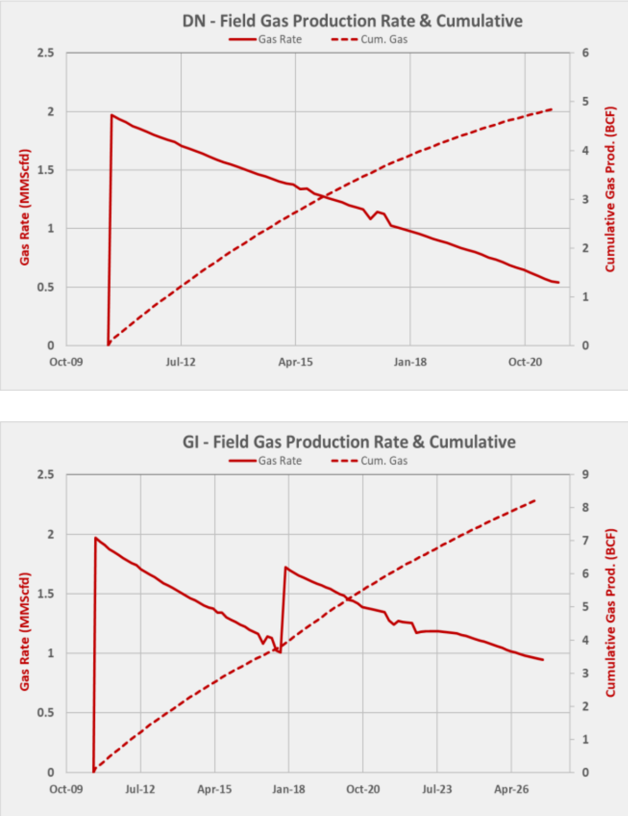


Fig.11 Gas Production Rate of Field

3.1.4 Pressure Trend in the Reservoir of Vertical DN vs Vertical GI

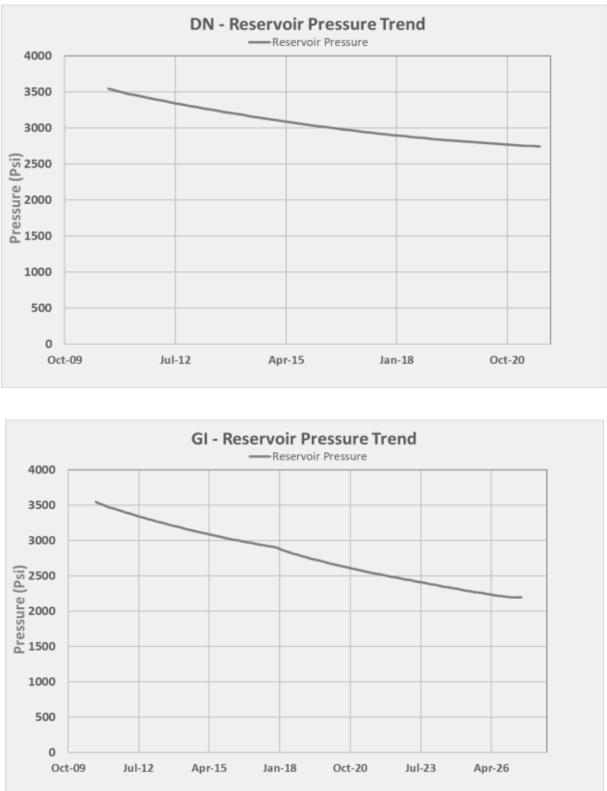


Fig.12 Pressure Trend in Field

It is clearly stated from the results presented in Figure 12 that, when using a Vertical GI Coupling the pressure of the field and wells drops slightly. This represents the pressure trend in a field with vertical DN shows less pressure drop while vertical GI has more loss in pressure trend.

3.2 Production results of horizontal DN and AGL

3.2.1 Oil Production rate of horizontal DN and AGL

The use of AGL horizontal coupling has great impact on the overall oil production. The below figure is comparison of DN vertical and AGL horizontal coupling which clearing indicates that AGL horizontal coupling has greater rate of overall oil production in the field in comparison with DN vertical.

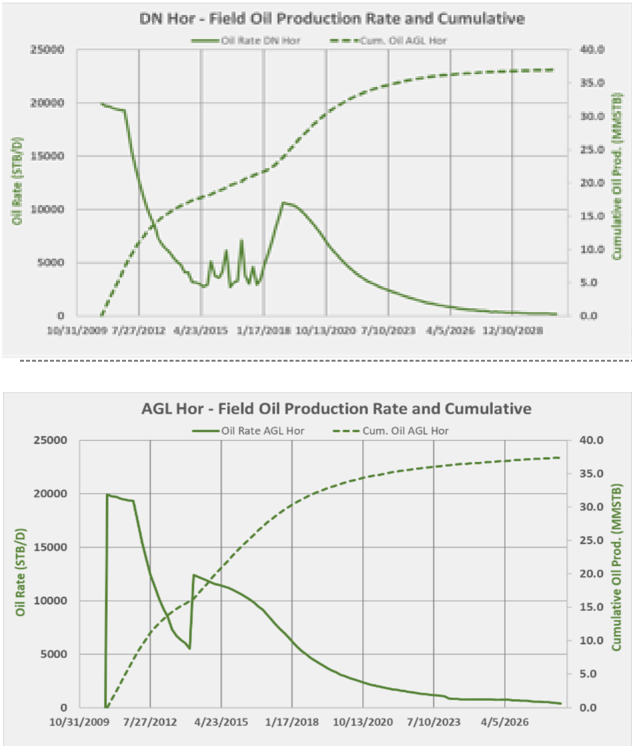


Fig.13 Oil Production of Field

3.2.2 Water Production rate of horizontal DN and AGL

One of the things which creates problem in the oil fields is high amount of water produced within a field that may lead to exhaustion of well and effect the production. More the water less the pressure of a reservoir, the decrease in the pressure of well drop the oil production significantly. However, water presence and production in a field should be continuously monitored to smoothly operate the well. Figure 14 represent the cumulative water produced from the field using AGL Horizontal was higher in comparison DN Horizontal shows low water production.

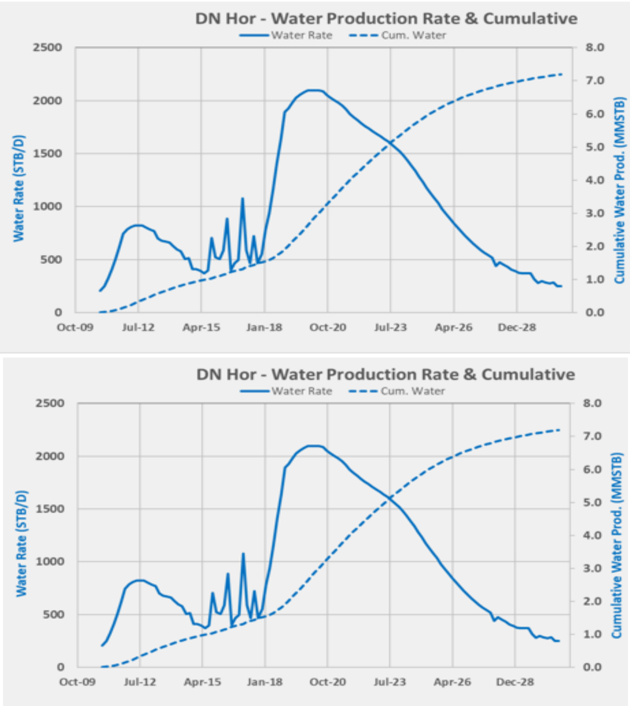


Fig.14 Water production of field

3.2.3 Gas Production rate of horizontal DN and AGL

The cumulative Gas production in the field using AGL Horizontal was higher in comparison with DN Horizontal shows low gas production. As Clearly shown in the figure when using AGL Horizontal the gas recovery increases early April and went to peak by January while when using DN Horizontal the rise starts after January.

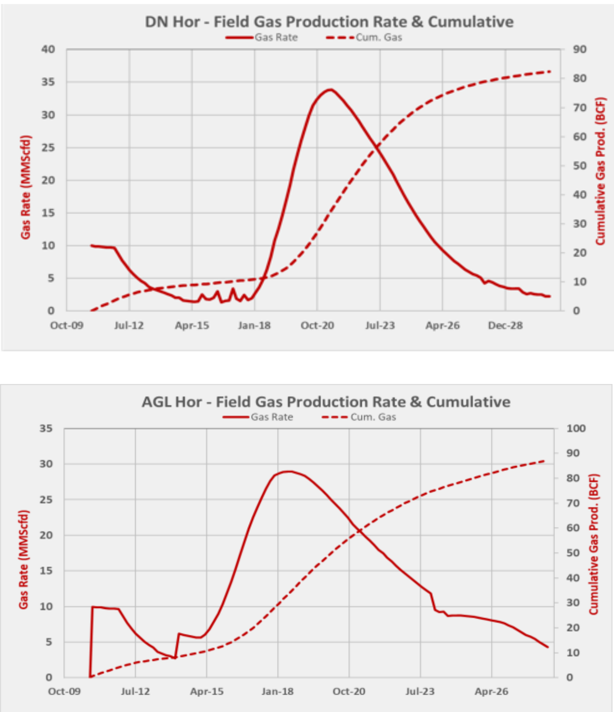


Fig.15 Gas Production of Field

3.2.4 Pressure Trend in the Reservoir

The pressure trend in the field it represents that while using AGL Horizontal the drop in pressure is uniform over the period of time while the pressure trends in DN Horizontal are different they are not uniform and vary with time. In case of AGL because the oil recovery starts early so the pressure also drops early. Whereas, in DN Horizontal the production started late that's why the pressure is constant after July.

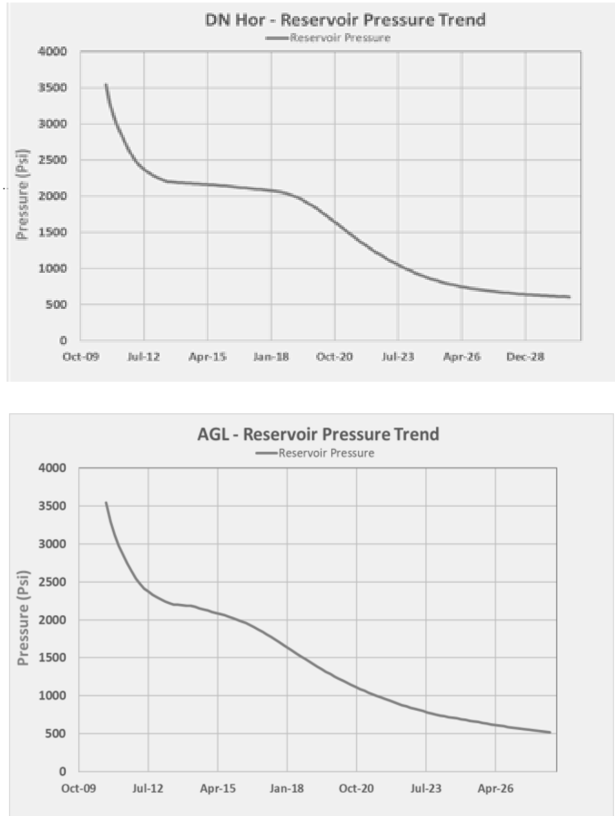
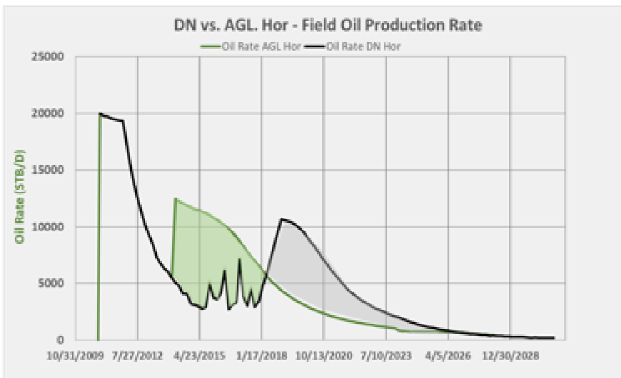


Fig.16 Pressure Trends in Field

3.3 DN vs AGL horizontal oil production

The cumulative oil production comparison of DN and AGL, it clearly shows that when using AGL Horizontal the oil production increases early shown whereas in DN oil rate increases slowly over the period of time. The cumulative oil recovery in case of AGL was higher.



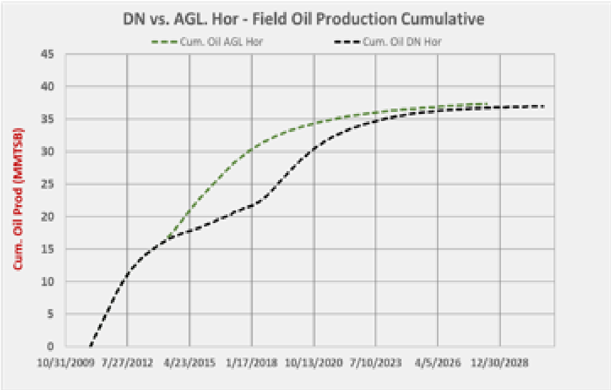


Fig.17 DN vs AGL Horizontal Oil Production

3.4 DN vs AGL Horizontal Gas Production

The cumulative gas production comparison of DN and AGL, it clearly shows that when using AGL Horizontal the gas production increases early shown whereas in DN gas rate increases slowly over the period. The cumulative gas recovery in case of AGL was higher.

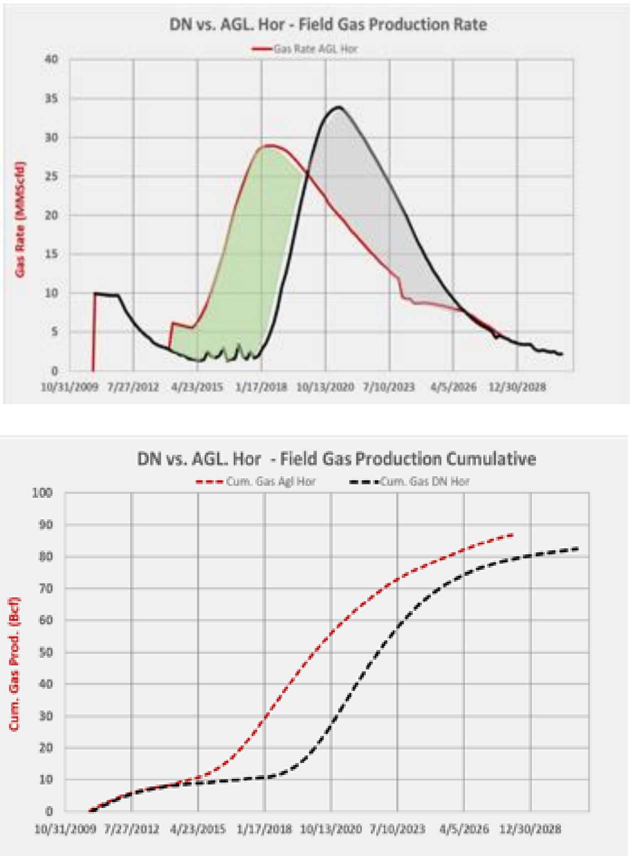


Fig.18 DN vs AGL Horizontal Gas Production

3.5 Comparison of all cases results

The graphical representation of all the cases. In terms of cumulative oil production AGL shows the highest amount of oil recovered, whereas DN Horizontal Shows minimum oil production. In terms of gas production AGL shows maximum gas recovery and DN showed minimum recovery. The depletion is pressure was also highest in AGL and lowest in DN.

Fig.19 Graphical Comparison of all results

The comparison of all the cases. In terms of cumulative oil production AGL shows the highest amount of oil recovered, whereas, DN Horizontal Shows minimum oil production. In terms of gas production AGL shows maximum gas recovery and DN showed minimum recovery. The depletion is pressure was also highest in AGL and lowest in DN.

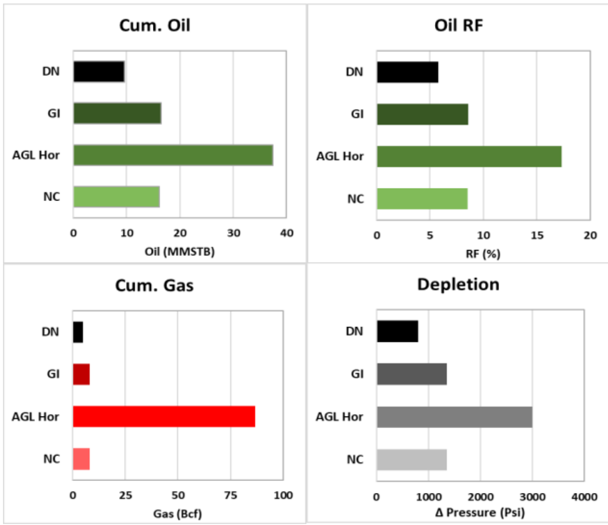


Fig.20 Cumulative Comparison of all results

Conclusion

The pressure of the reservoir declines over a period of time, and this process is continuous, this happens because the drop in overall production. In order to increase the rate of production gas lift technology promotes continuous extraction from wells by decreasing the hydrostatic head of the fluid column within a well. Moreover, gas lift systems according to various studies are proven to be most cost efficient and economic viable technology that can increase the oil production rate from a filed by up to 50%.

Through a series of progressive engineering studies using MBAL and PROSPER several simple conclusions can be made based on information and data provided and implied in this paper

- When using AGL the overall Oil and Gas production from Field and Wells increases significantly.
- The cumulative Oil production of AGL Horizonal was highest in comparison with DN, GI and NC.
- The cumulative Gas production of AGL Horizonal was highest in comparison with DN, GI and NC.
- The Lowest Oil Production was observed in Field, well 1,2 and 3 when using DN coupling.
- The Lowest Gas Production was observed in Field, well 1,2 and 3 when using DN coupling.

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