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PRODUCTION OPTIMIZATION OF SRIKAIL GAS FIELD BY NODAL ANALYSIS

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Abstract: Production Optimization is the approach for maximizing the recovery of a gas field. It is simply a balance between reservoir and well deliverability by keeping pace with demand. Currently when Bangladesh facing energy crisis, optimization of a vital productive field can serve this purpose much. Maximizing the recovery through production optimization can elongate the life of the system preventing abandonment. Taking care of these facts this paper attempts to optimize the production rate of Srikail gas field. Nodal analysis technique is applied to obtain the optimum gas flow rate with respect to the wellhead and reservoir pressure. This paper has dealt with the Srikail well-2. IPM Petroleum Expert tool PROSPER has been used to model the well, to optimize the current flow rate and further sensitivity analysis has been done to achieve improved IPR and VLP curves and hence an improved production rate.

Keywords: IPR, VLP, Nodal analysis, Production optimization, PROSPER

1. INTRODUCTION

Production optimization is a noble approach for maximizing the recovery and productivity of petroleum fields. To optimize the production performance data of reservoir inflow, wells outflow performance, surface facilities, pressure restrains are required. Nodal analysis is a systematic procedure applied to the enhancement of production of oil and gas well by analyzing and evaluating the complete production system. Pressure drop calculation through the whole system is necessary to apply the nodal analysis procedure. Pressure drop depends on tubing, piping and valve size; flow rate will be analyzed using the concept of reservoir engineering, inflow and outflow performance, tubing and flow line performances.

1.1 Location of the field

Bangladesh is standing on a young deltaic sedimentary basin that serves the geologic requirements for the generation and accumulation of natural gas in the subsurface. The eastern part of the country has been proved to be a natural gas rich province with several gas fields discovered. Among this fields Srikail is worth mentioning as this field has been performing as a highly productive field for the last several years.

Srikail is surrounded by several anticlinal structures. Bakrabad to south-west, Saldanadi to the east, Lalmai and Bangora to the south, and Titas to the north-east. The area is located in Muradnagar Upazilla of Cumilla district under Chittagong Division of Bangladesh. Srikail structure is located about 35 kilometer north-west of Cumilla. It lies in the central part of Block-9, approximately 60 kilometers east of Dhaka city. [1, 2]

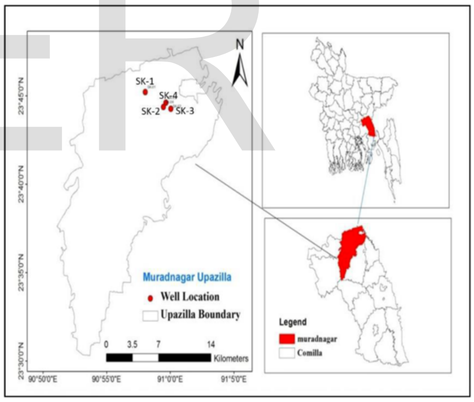

Fig. 1. Locational map of Srikail gas field

1.2 Petroleum System in Srikail Gas Field

Seven hydrocarbon bearing zones (A, B, C, D, E, F & G) have been discovered in the study area. Among them the well Srikail-4 and Srikail-3 have passed through the D-sand, Srikail-2 has encountered three gas sands i.e. B, D and E sand and the well Srikail-1 has encountered none of these seven layers instead, it went through some clay layers. So, these are the producing wells well - 2, 3, 4 out of all four wells. [6] The average shale volume of hydrocarbon bearing pay zones of the studied area ranges from 8% to 38%. The layers A to C shows an increasing trend while the layers D to F shows something opposite. This bi-model distribution of grain size might be the result of fluctuating energy condition of paleo-depositional environment. Again, increasing trend is shown by G sand. A sand shows the least volume (8%) where B sand shows the most (38%). [6] The estimated average effective porosity of hydrocarbon bearing pay zones ranges from 12.3% to 24.9%. G sand shows the maximum average effective porosity (24.9%) while the minimum porosity is found in D sand (13%). The porosity values of A, B and G zone are higher (above 20%) than the other zones. The porosity values exhibit that the hydrocarbon-bearing zones are good in categories. From the effective porosity ranges the hydrocarbon saturation is determined.

Hydrocarbon saturation ranges from 53.1%-75.1% of gas in the reservoirs indicating all the zones well saturated with hydrocarbon. The range of average effective water saturation in pay zones is 24.9% to 46.9%. C sand shows the maximum effective water saturation (46.9%). Then A and F, B, D, E follows by and the lowest water bearing layer is G sand (24.9%). The water saturation for each hydrocarbon bearing zones indicates that the zones are well saturated with hydrocarbon and are productive. The estimated average net thickness ranges from 1.3m to 23.08 m. C sand is the thinnest layer (1.3 m) whereas D sand is the thickest (23.8m). That is why this zone bears the testimony of both lower and higher potentiality of hydrocarbon accumulation respectively. The average net thickness of A, B and C sand is comparatively lower than the average value of D, E, F sand which represents the greater potentiality of hydrocarbon reserve. [6]

1.3 Objective of this study

This study helps to determine the optimum flowrate of existing gas well, Srikail-2. It also analyzes some components of production system whether these components are creating any flow restriction or not. Finally, it optimizes the production system by Nodal analysis method. In this method the total production system will be analyzed by taking consideration of tubing size, flowline size and depletion effect.

1.4 Previous Study

There have been a little number of studies on Srikail gas field. A last study in December, 2017 was done by Md. Imam Sohel Hossain, A.S.M. Woobaidullah* and Md. Jamilur Rahman. In that study they tried to determine the petroleum system of the study area by using sequence stratigraphy. The finding of the study told that the petroleum system of the studied area was very prospective in terms of hydrocarbon accumulation. [1]
Recently a study on Srikail gas field has been done by them [6] in which they characterized the field by determining the shale volume, average porosity, water saturation, gross thickness, net thickness, gross to net thickness. From which they determined the hydrocarbon saturation in the seven gas bearing zones and the reason behind the non-productivity of Srikail well-1. [6]

2. WELL PERFORMANCE ANALYSIS BY PROSPER

2.1 PROSPER Model

PROSPER is a single well characterization program. Its output is principally Inflow Performance Relationship (IPR) and Vertical Lift Performance (VLP). These relations respectively describe the inflow to the well sand face from the reservoir and the outflow from the well sand face to the wellhead at the top of the well. These pressure and flow relations are heavily reliant on the PVT characteristics of the produced fluid. Using inflow and outflow, we understand the behaviour of the well in terms of the flow rates vs. bottom hole pressures (BHP) for a given mean reservoir pressure. [9]
In this study, PROSPER software is used for determining reservoir deliverability of Inflow Performance Relationship (IPR) curves for each individual well from the deliverability test data obtained using flow after flow test procedure and well deliverability or Vertical Lift Performance (VLP) curves using best matched tubing correlations for the individual wells. Then nodal analysis theory is applied for the corresponding system conditions such as, WGR, CGR, wellhead pressure, reservoir pressure. Sensitivity analysis of varying tubing diameter on gas rate had been performed in order to check the quality of existing tubing string design.

2.2 IPR Data

The IPR data were loaded to run a dry and wet gas model based on the data and completion diagram. The data for IPR was put on the base of reservoir pressure 3232.3 psig enabling production test data August- 2018. Using the model "Jones" the IPR model of Srikail well- 2 has shown in Figure 2.

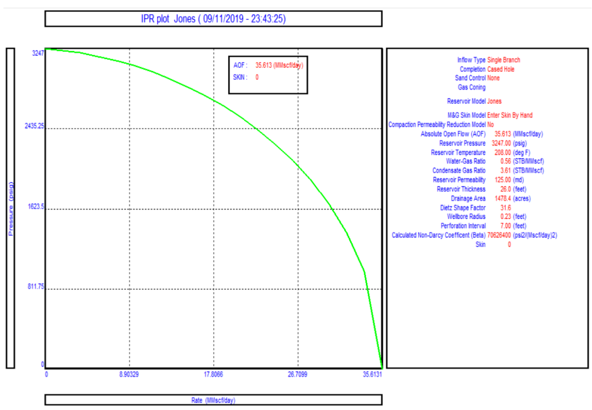

Fig. 2. Srikail well-2 IPR model using Jones model

2.3 Equipment Data

As input data, the deviation surveys, geothermal gradient, down-hole equipment data and tubing size are used here. The surface equipment data was avoided as these data were not available. Using the provided information PROSPER has drawn the down-hole configuration as the Figure 3.

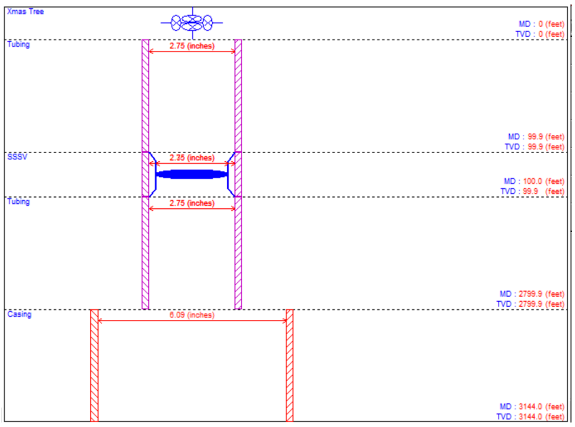

Fig. 3. Down-hole equipment drawing of Srikail well-2

2.4 VLP Plot

This option calculates the VLP response. For accomplishing the tubing curve calculation, the Top node pressure, WGR, CGR was loaded into the software. The correlation was chosen and corrected through the VLP/IPR matching option.

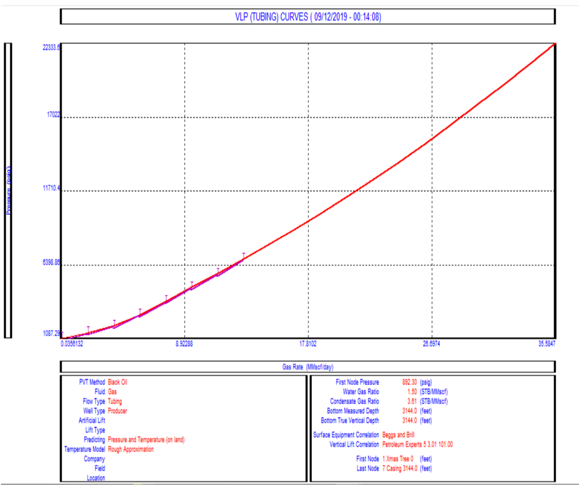

Fig. 4. VLP (tubing) curve plot

2.5 Matching VLP/IPR (Quality Check)

In the VLP/IPR matching option, the production test data, such as down-hole pressure gauge depth, measured pressure at certain gas flow rate, WGR, CGR, tubing head pressure and tubing head temperature were entered and the overall heat transfer coefficient (U) was determined. Then PROSPER compares the various tubing correlations were against the test point. The best correlation was tuned with the test point by "Match VLP" option. Finally, VLP was generated using the chosen correlation and matched with IPR curve that was previously generated. If there was any clash observed in the VLP/IPR matching curve, the IPR curve was adjusted slightly by changing its parameters to match with the VLP curve as presented in Figure 5. [11]

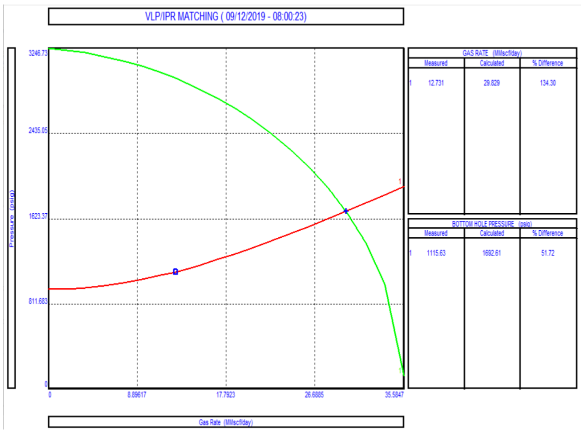

Fig. 5. VLP/IPR matching of Srikail well-2

2.6 System Analysis

This option calculates both tubing outflow and inflow. It also determines system operating rate and bottom hole flowing pressure (BHFP). It also allows to perform sensitivity analysis with as wide range of variables that can be entered simultaneously. The range of choice of variables that can be sensitized on is determined by the model.

IPR is calculated using the test data August-2018. To calculate the IPR plot of Srikail well-2 sensitivity variables used are listed in Table-1. Figure 6 and Figure 7 shows the variability in IPR for individual change in skin and perforation interval respectively. Next, Figure 8 shows the combined effect for change in skin, reservoir pressure and perforation interval.

Table-1: Sensitivity variables for Srikail well-2

	Variables	Input Values
1.	Skin	-1, 2, 4, 6
2.	Reservoir Pressure (psig)	1400, 2100, 2700, 3200
3.	Perforation interval (feet)	4, 5, 7.5, 9

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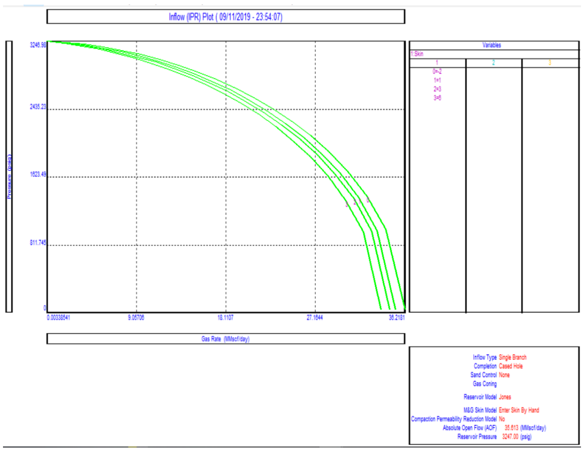

Fig. 6. IPR plot for variable skin in Srikail well-2

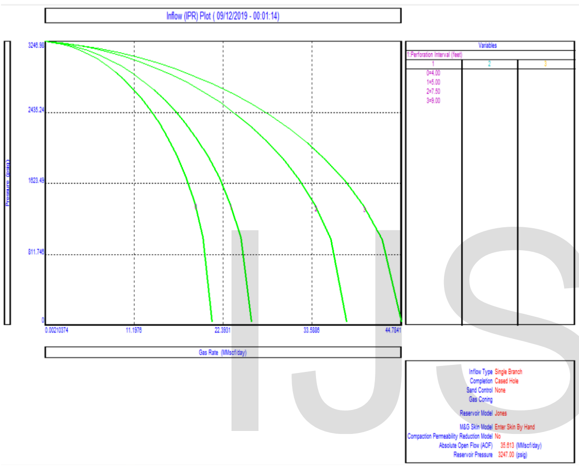

Fig. 7. IPR plot for variable perforation interval in Srikail well-2

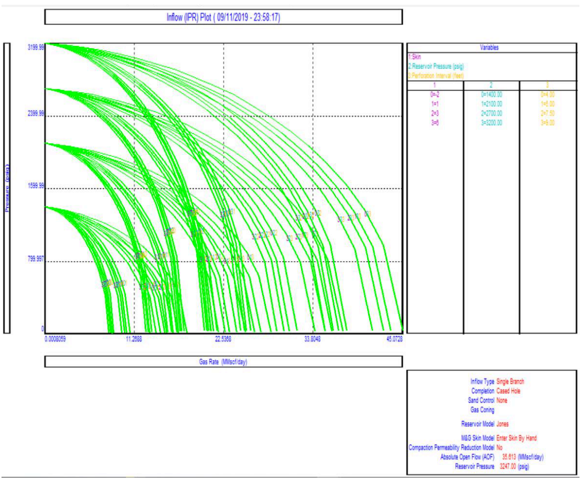

Fig. 8. IPR plot with changed variables

VLP is too calculated from the same data collected from August-2018. For sensitivity analysis of well deliverability WGR, CGR and First node pressure is taken as variables. The changing range of the mention variables are given in Table-2. And Figure 9 shows the VLP plot with the variability.

Table-2: Sensitivity variables for VLP plot

	Variables	Changing range
1.	Water Gas Ratio	.3, .533, .766, 1
2.	Condensate Gas Ratio	3, 4.33, 5.67, 7
3.	Top Node Pressure	899.00, 954.00, 1001.00, 1124.00

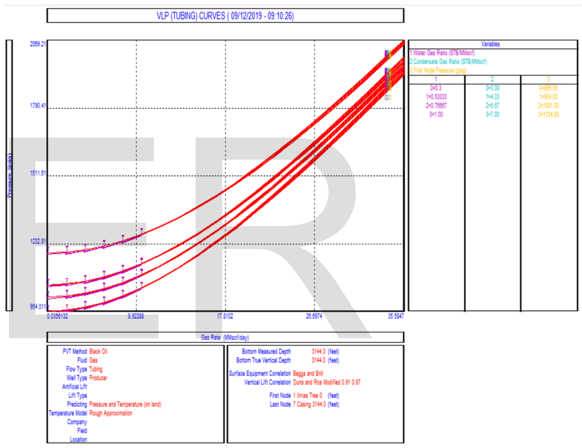

Fig. 9. VLP plot of changed variables

2.7 System IPR+VLP

This option deals with the final cross-plot of inflow and outflow curves. The initial plot is obtained based on data of August-2018. Figure 10 shows the optimization result. The optimum gas rate and bottom-hole pressure are respectively 29.064MMscfd and 1788.04psig. The correlation "Petroleum Expert – 2" has been selected for vertical lift correlation and determined the system operating rate. Figure 11 shows a combined result of system output with changed variables. Here First node pressure, WGR, perforation interval has been taken as sensitivity.

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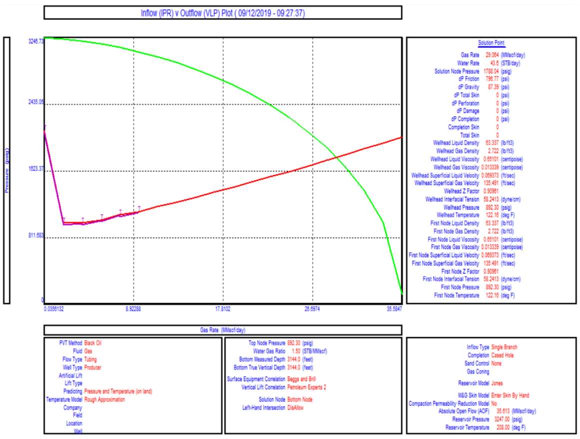

Fig. 10. System output

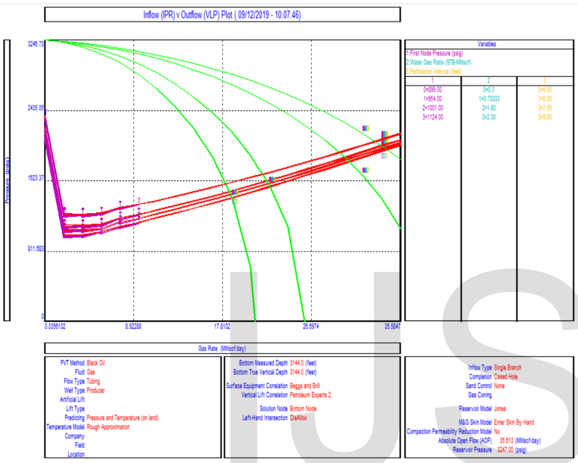

Fig. 11. System output with sensitivity components changed

3. RESULTS AND DISCUSSION

If we sum up all these experiments by changing wellhead pressure, water gas ratio and perforation interval we get these results of optimum flowing rate and bottom hole pressure. The results are shown below in the Table-3.

Table-3: System calculation results of Srikail well-2

	Well head pressure (psig)	Water Gas Ratio	Perforation Interval (feet)	Gas rate (MMscfd), Bottom-hole pressure (psig)
1.	899.00	0.3	4	19.812, 1420
2.	954.00	0.733	5	23.56, 1590
3.	1001.00	1.8	7.5	29.53, 1870.9
4.	1024.00	2.3	9	32.23, 2104

From the system plot generated using Petroleum Expert, PROSPER 11.4 tool we can see the observed production rate of the Srikail well-2 that is almost 29 MMscfd based on the real field data obtained of Srikail gas field. After analysing various sensitivity conditions, we can see that the gas production rate can be optimized up to 32.23 MMscfd.

4. CONCLUSIONS

The total optimization work summarized comprises modeling of the Srikail well-2, generation of IPR & VLP models, matching IPR/VLP and sensitivity analysis due to change in effecting components.
From different sensitivity analysis it is shown that wellhead pressure, perforation intervals are sensitive, skin are sensitive factors for optimizing the flow rate. From the different flow test results, we see that with the gradual decrease in reservoir pressure the flow can be increased via decreasing skin, perforation interval for a given wellhead pressure. Also a decreased well head pressure increases flow rate too.
The well is now in its youth as its producing only for 8 years and according to provided data from the field it is facing now zero skin. But gradually with time skin value will increase with additional pressure drop demand. A compressor might help then to hold the productive flow rate. If the reservoir pressure reduces up to 1500 psig and the FWHP is set at 300 then the flow rate ranges within the range 10 to 13 MMscfd with BHP ranging in between 750 to 1000 psig. At that condition a compressor could help to maintain an increased acceptable well head pressure with an economic flow rate.

REFERENCES

[1] MD. IMAM SOHEL HOSSAIN, A.S.M. WOOBAIDULLAH AND MD. JAMILUR RAHMAN, December 2017 “Petroleum System of Srikail Gas Field Using Sequence Stratigraphy”
[2] “Annual Report 2009”, Bangladesh Oil, Gas & Mineral Corporation (PETROBANGLA), Dhaka, Bangladesh.
[3] “Annual Report 2018”, Bangladesh Petroleum Exploration and Production Company Ltd. (BAPEX) http://www.bapex.com.bd/?page_id=29364 (Accessed on 11th September, 2019)

International Journal of Scientific & Engineering Research Volume 11, Issue 2, February-2020
ISSN 2229-5518

[4] Exploration History of Bangladesh http://energy-resource.blogspot.com/2013/03/exploration-history-of-bangladesh-in.html (Accessed on 10th September, 2019)
[5] MICHAEL J. ECONOMIDES, LUIGI SAPUTELLI, "Production Optimization"
[6] MD. IMAM SOHEL HOSSAIN, A.S.M. WOOBAIDULLAH AND MD JAMILUR RAHMAN, "Reservoir Characterization of Srikail Gas Field Using Wireline Log Data"
[7] BADRUL IMAM, "Energy resource of Bangladesh: natural gas, oil, coal", University Grants Commission of Bangladesh, 2005, ISBN: 9848090201
[8] BEGGS H. D., "Production Optimization Using Nodal Analysis", OGCI and Petroskills Publications, Tulsha, Oklahoma, USA.
[9] Petroleum Experts, PROSPER, "Single well system analysis user guide manual" Version 11.5.
[10] MICHAEL J. ECONOMIDES, A. DANIEL HILL, CHRISTINE EHLIG-ECONOMIDES, "Petroleum Production System, 2nd Edition".
[11] Petroleum Experts, PROSPER, "Single well system analysis user guide manual", Version 11.5.

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