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Production Forecasting of Bakhrabad Gas Field Using Decline Curve Analysis

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Abstract

Energy demand is escalating in Bangladesh with its growing population. Natural Gas is one of the major energy sources in Bangladesh. This paper opts for the production prediction of Bakhrabad Gas Field as it contributes to the national energy demand largely. Bakhrabad Well-3,8,9 and 10 are the main focus of this study. Production forecasting was carried out to analyze the longevity of these wells, also to identify their capability to meet the energy demand in the long run. This research employed decline curve analysis technique in an association with MBAL simulation software. To get the anticipated results, historical production data was supplied into MBAL. The aforementioned gas wells are discovered to undergo exponential type production decline. The remaining well life calculation's findings indicate that these wells will permanently shut down by 2033. Future cumulative production of these four wells are predicted to be 10.2615Bcf, 14.1379Bcf, 8.3838Bcf and 1.566476Bcf respectively by MBAL.

Keywords: Gas Production Forecast, Decline Curve Analysis, MBAL, Cumulative Production.

1. Introduction

Gas production forecasting is the technique of predicting future natural gas production from natural sources. It has become an increasingly significant activity in the oil and gas sector for a number of reasons, including resource allocation, infrastructure planning, investment decisions, operational efficiency, and supply and demand balancing. Bangladesh has 28 operational gas fields. Bakhrabad Gas Field is one of the largest gas fields of this country. Production forecasting becomes increasingly important as Bakhrabad gas field meets the gas needs of a significant number of consumers. Alarmingly, Bangladesh is projected to run out of gas by 2030[1]. As a result, it is crucial to estimate this field's recoverable reserve until 2030 using production forecast. Numerous studies have already been conducted on the Bakhrabad Gas Field, including one that used the flowing well method for the material balance study for "J" sand. To estimate the gas initially in place (GIIP) of 'J' sand, three approaches were made. These approaches, which produced GIIP results of 460.50 BCF, 469.5 BCF, and 455.36 BCF, respectively, were flowing bottomhole pressure, flowing well head pressure, and static bottomhole pressure[2]. Furthermore, reservoir diagnosis revealed indications of pseudo-steady state flow regime in producing wells, and the AWMB technique observed volumetric depletion with no existing aquifer support. Authors also recommended further studies on production forecasting using numerical or analytical models[3]. After reviewing the available literature on this gas field, it is evident that a detailed gas production forecasting study is required for determining the remaining lifespan of this field as well as forecasting gas production. This research focuses on the forecasting of gas production from Bakhrabad Gas Field's Well-3, 8, 9, and 10 which are located in the major pay zones (gas sand) G, J, and K. The objectives of this study are: to evaluate the production decline type, to determine the remaining life period for the selected wells and to determine the cumulative total gas production for individual well for the remaining life period. Decline Curve Analysis has been used as a production forecasting tool to accomplish the study's goal due to its simplicity and less complex approach. The decline type of gas production was first determined in order to undertake the investigation. The well life was then calculated, and lastly a production forecast was generated.

2. Methods

Decline Curve Analysis (DCA)

The method of linking production to time is referred to as decline curve analysis[4]. DCA is an approach for predicting future production rates, evaluating gas reserves, and determining remaining productive life[5]. J. J. Arp (1945) initially described decline curve analysis. He developed various empirical decline curves in

order to forecast reserves[6]. For producing wells, Arps investigated the link between flow rate and time. He discovered a link by assuming constant flowing pressure and that is[4]

$$\frac{dq}{dt} = -Dq^{(b+1)} \quad (1)$$

Where, D and b are empirical constants, and b is a variable that can range from 0 to 1. There are three types of decline curves that are frequently recognized. These are, Exponential Decline, Harmonic Decline, Hyperbolic Decline.

Table 1. The rate-time relation for decline types yield the following equations[7]

Exponential	Harmonic	Hyperbolic
$q = q_i e^{-Dt}$	$q = \frac{q_i}{(1+Dt)}$	$q = \frac{q_i}{(1+bDt)^{\frac{1}{b}}}$

Here, q = flow rate at time t, MMscf/day, q_i = initial flow rate, MMscf/day, t = time, day, D = decline rate, 1/day, G_P = Cumulative Production, MMscf.

The conventional DCA method is based entirely on the observed trend in the production decline and fits a curve based on the reservoir's projected behavior. Such a model is not affected by operating conditions[8].One of the objectives of this study is to identify the production decline type these gas wells have undergone which is the first prerequisite of production forecasting through DCA. Therefore, semi-log plots of rate against time for each well is generated using MBAL software to determine the decline type. The factors needed to determine well life are the decline rate (D), the initial flow rate (q_i), and the economic limit (q) for each well. The MBAL software used the production history data of each well as input to determine the decline rate. Production history data includes the production rate (MMscf/day) and cumulative production (MMscf). "Petrobangla (Bangladesh Oil, Gas & Mineral Corporation)" provided all of the necessary production history data of Bakhrabad Gas field for this work. Petrobangla is Bangladesh's state-owned natural gas corporation. This corporation discovers, manufactures, transports, manages, and sells oil, natural gas, and other minerals. As the all four gas wells showed exponential decline, hence the equation mentioned in Table 1 is used to calculate the well life. Following that, the production prediction setup is run to determine the future production trend.

MBAL Workflow

MBAL is a commercial reservoir engineering tool created to support reservoir analytical study. This tool has a variety of uses. However, this study used MBAL algorithms to forecast cumulative gas production through history matching.

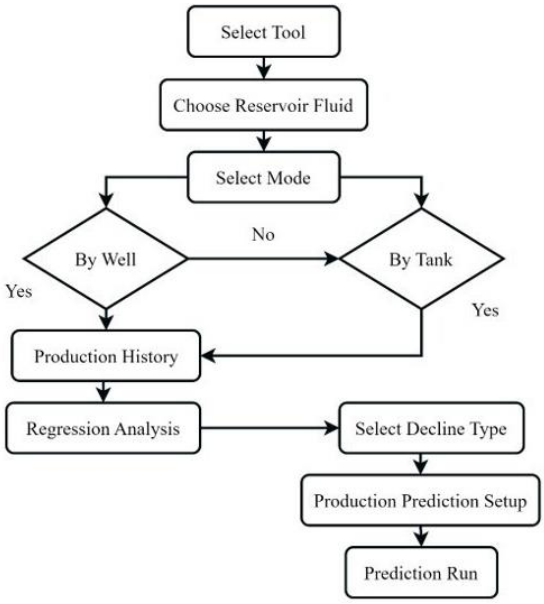


Fig. 1. Workflow diagram of MBAL software

MBAL accepts historical production data as input parameters. It supports three types of decline curve mathematical models that explains the production decline over time. It fits the input data points to one of the three decline curve models through regression analysis. This method entails optimizing the parameters (initial production rate, decline rate) in order to reduce the error between the model's predictions and the actual data. After fitting a decline curve, MBAL extrapolates it forward to predict future production rates.

This software applies DCA to extrapolate future production trends, assuming that the decline rate follows a constant pattern over time. MBAL is a widely used industry-standard software developed primarily for reservoir engineering purposes. This tool provides comprehensive features for assessing and modelling reservoir behavior. It has also been used in earlier research to estimate the initial reserve and anticipate the future performance of the reservoir[9]. Fig.1 presents the simulation procedure of MBAL software.

3. Results

MBAL simulation software works on history matching. After doing regression analysis on the production history provided to the software, the decline rate (D) was received as an output. The decline rate is a significant parameter in this study since MBAL estimated the future cumulative production based on the production history input.

Decline Type Diagnosis and Remaining Well Life Calculation

A summary is presented in Table 2 showing the outcomes of decline diagnosis and well life calculation. Fig.2 and Fig.3 are the representation of production rate vs time generated by MBAL for four wells respectively.

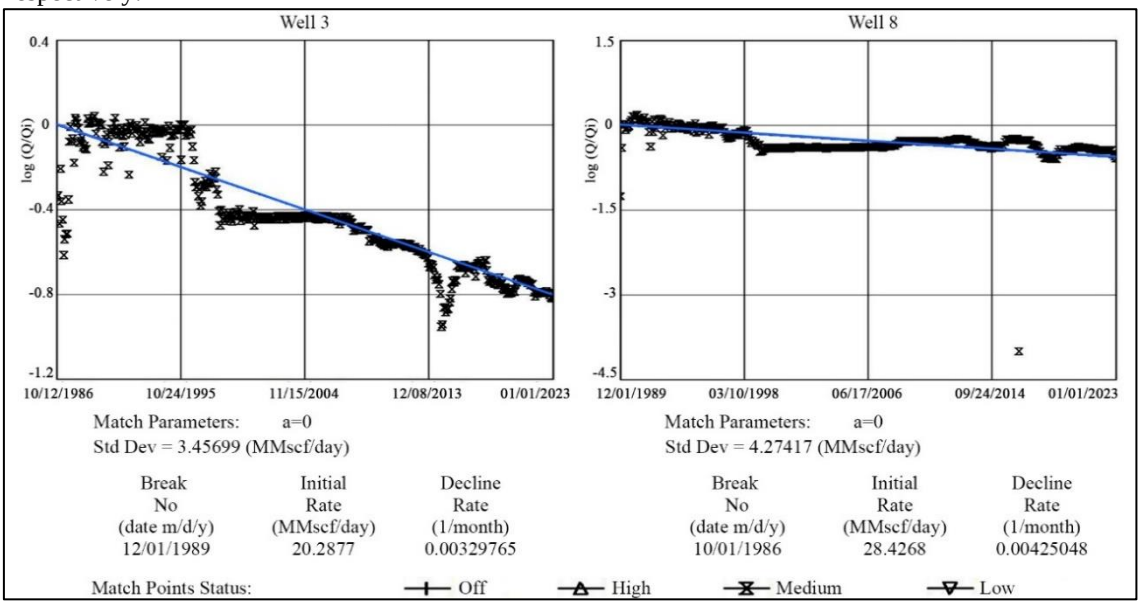


Fig. 2. Semi-log plot showing decline rate for well-3 & 8

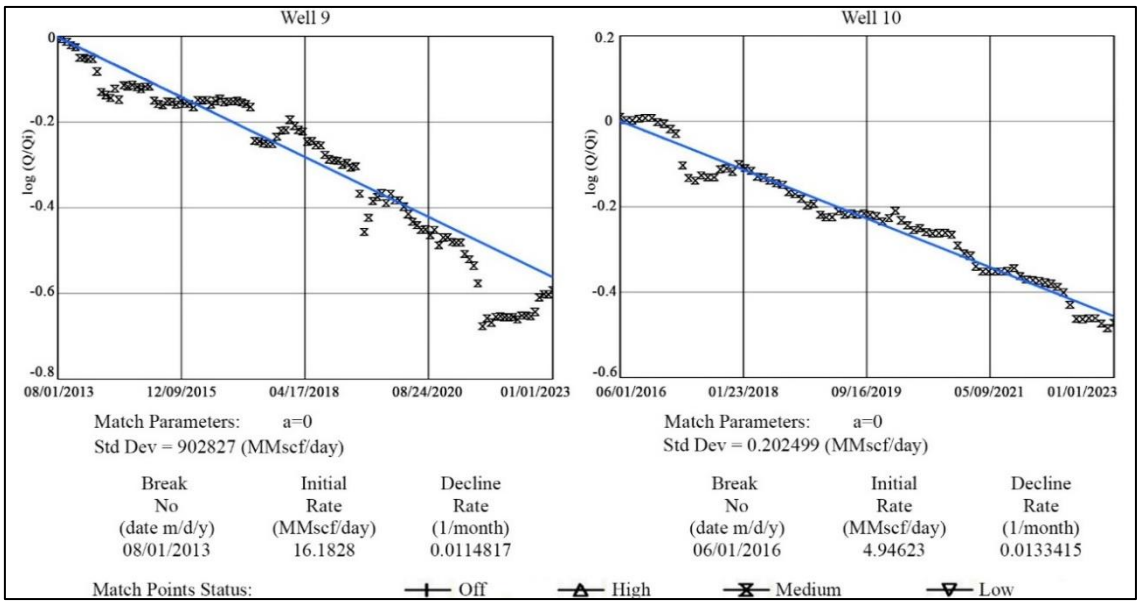


Fig. 3. Semi-log plot showing decline rate for well-9 & 10

Table 2. Decline type and remaining well life summary of Bakhrabad Gas Field's producing wells

Well No.	Production History Available	Remaining Life (End of Well Life)	Decline Type
Well-3	October'1986-Janary'2023	$t = \frac{-\ln(\frac{2.8}{4.30816})}{0.00425048} \approx 8$ Years, (Year 2031)	Exponential
Well-8	December'1989-Janary'2023	$t = \frac{-\ln(\frac{3.65}{5.27223})}{0.00329765} \approx 9$ Years, (Year 2032)	Exponential
Well-9	August'2013-Janary'2023	$t = \frac{-\ln(\frac{1}{4.13758})}{0.0114817} \approx 10$ Years, (Year 2033)	Exponential
Well-10	June'2016-Janary'2023	$t = \frac{-\ln(\frac{1}{1.66945})}{0.0133415} \approx 3$ Years, (Year 2026)	Exponential

Production Prediction

The economic limit (q) is an important parameter in production forecasting. The term "Economic limit" refers to the minimum rate below which gas production is no longer profitable. The value of this parameter was assigned to MBAL for each well individually. Hence, divergence exist in predicted production of these four wells. MBAL generated a production projection correlating historical data, decline rates, and economic limits. Fig.4 and Fig.5 are the graphical presentation of cumulative production after simulation.

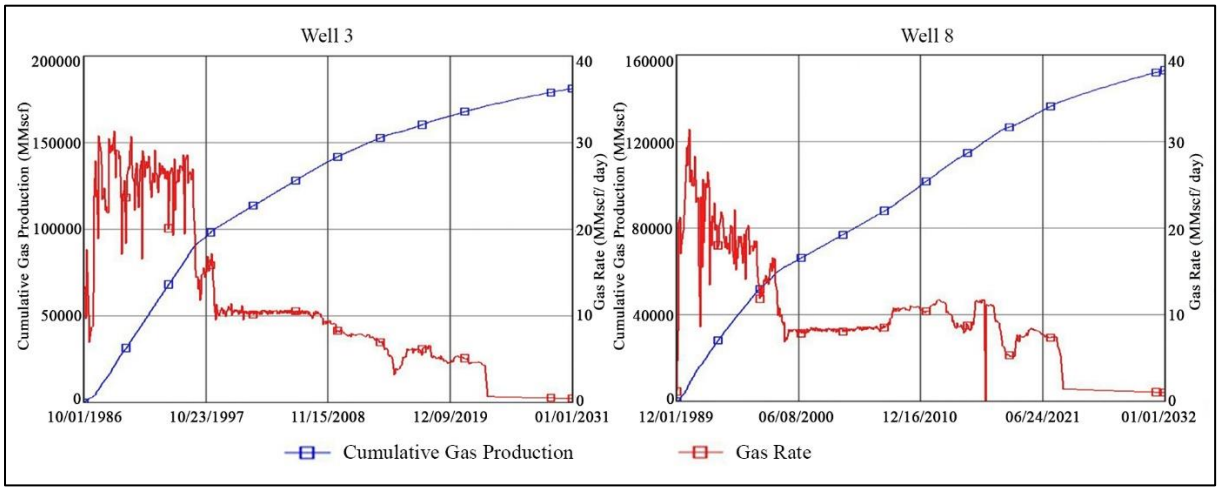


Fig. 4. Predicted cumulative production of well- 3 & 8

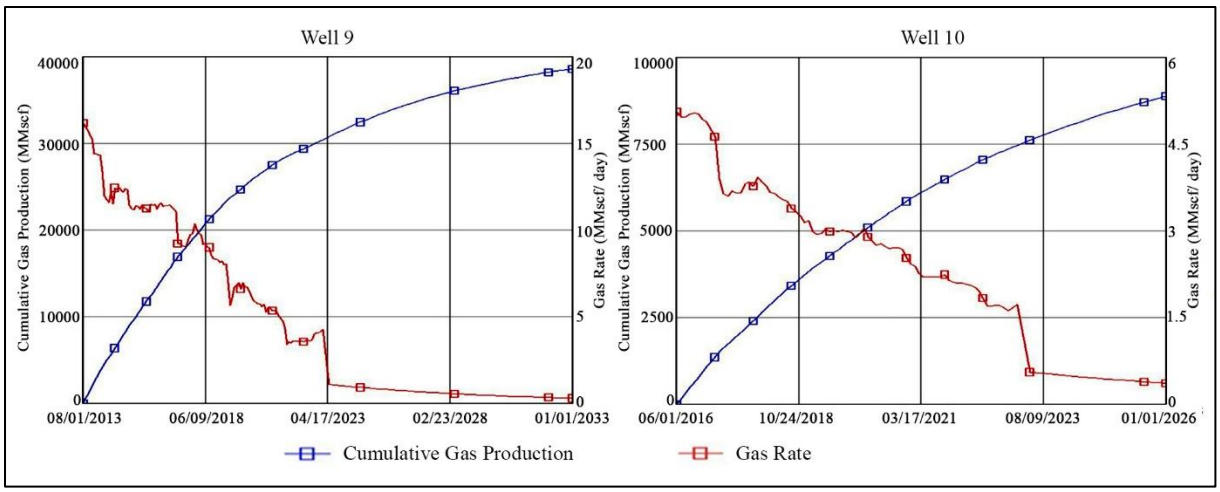


Fig. 5. Predicted cumulative production of well- 9 & 10

Table 3. Future production of Bakhrabad Gas Field's producing wells.

Well No.	Cumulative Production (G_p) History	Predicted G_p from Feb'23 to End of Well Life
Well-3	October'86-January'23 = 170.9045Bcf October'86-January'31(Simulated) = 181.166Bcf	February'23-January'31 = 10.2615Bcf
Well-8	December'89-January'23 = 138.8641Bcf December'89-January'32(Simulated) = 153.002Bcf	February'23-January'32=14.1379Bcf
Well-9	August'13-January'23 = 30.2209 Bcf August'13-January'33(Simulated) = 38.6047 Bcf	February'23-January'33 = 8.3838Bcf
Well-10	June'16-January'23 = 7.315964Bcf June'16-January'26 = 8.88244Bcf	January'23-January'26 = 1.566476Bcf

As mentioned before, these four gas wells belong to gas sand - G, J, and K. Gas Initially in Place (GIIP) of these sands are 257 Bcf, 571 Bcf and 137 Bcf, respectively. Till January 2023, 222.82Bcf, 443.65Bcf and 7.31Bcf of gas have been produced from these sands. It is apparent that 34.18 Bcf, 127.35 Bcf, and 129.69 Bcf of gas are still present in these sands respectively. However, production forecasting revealed that the producing wells from these sands are only capable of extracting 18.64 Bcf, 14.13 Bcf, and 1.56 Bcf from the residual reserve during their remaining lifespan. Therefore, it is evident that these producing wells don't have much time left to produce such a significant amount. Hence, it can be stated that, to enhance overall production within the remaining well life, several changes in production operation need to be undertaken.

4. Conclusion

The aim of this research is to forecast the gas production of Bakhrabad Gas Field in order to assess its capacity to supply natural gas in the long run. To do this, a number of considerations were undertaken, including identifying the decline type, estimating the remaining life of the gas wells, and lastly predicting cumulative production employing MBAL software. The followings appear to be the key findings:

- Production history of gas well-3,8,9,10 has depicted straight lines in semi-log plots indicating the exponential type of production decline.
- These wells have an estimated remaining lifespan of 8, 9, 10, and 3 years, respectively and will be abandoned within the next ten years. As a result, it is apparent that these four gas wells will no longer be operational by 2033.
- MBAL simulation software predicted the cumulative production for the remaining lifespan of these wells to be as low as 10.2615Bcf, 14.1379Bcf, 8.3838Bcf, and 1.566476Bcf, correspondingly. It will be impossible for these wells to produce the remaining reserves from G, J, and K sands in this brief period that their well life still has left unless the current production strategy is changed.

5. References

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