Journal of Petroleum Science and Engineering 103 (2013) 115–120

Contents lists available at SciVerse ScienceDirect

Journal of Petroleum Science and Engineering

journal homepage: www.elsevier.com/locate/petrol

Modeling and performance prediction for water production in CBM wells of an Eastern India coalfield

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ARTICLE INFO

Article history:
Received 23 September 2011
Accepted 19 February 2013
Available online 14 March 2013

Keywords:
CBM
dewatering
water influx
model
flow potential
well testing

ABSTRACT

Dewatering of coal bed methane (CBM) reservoirs is a very important part of methane production. Efficient production depends very much on the proper designing of the wells. In the present study, a comprehensive testing is conducted on 17 wells of a particular block in Eastern India and a general reservoir flow equation is modeled. Prediction of the water flow potential of a particular well using the derived flow equation helps in monitoring the variables of the artificial lift facility. The outcome of work can be used comprehensively to predict the future water and gas flow rates of simulated wells under the designed test.

1. Introduction

Faster depletion of conventional resources and increasing demand for clean energy force India to hunt for alternatives to conventional energy resources. Coalbed methane (CBM) and shale gas are two of the most promising and potential resources of natural gas. India has approximately 4.6 trillion cubic meters (DGH Report, 2009–10) of reserve which may fulfill the country's future growing energy demand to a large extent (Singh, 2002). However, production of gas from coalbed is very much different from conventional gas reservoir and requires utmost care and precautions in developing the production strategy.

Coal is a complex heterogeneous system with methane gas remaining adsorbed on coal surface by lithostatic and hydrostatic pressure. Production of gas is controlled by depletion in pressure of the reservoir. Flow mechanism follows a three step process: (a) desorption of gas from the coal matrix, (b) diffusion to the cleat system, and (c) flow through fractures (Thimons and Kissell, 1973). Mostly, coal reservoirs are water saturated, and water provides the reservoir pressure to hold gas in the adsorbed state. As a result, water saturation in CBM reservoir is often nearly 100%, and this water must be produced to lower the reservoir pressure below the saturation pressure of methane to get desorbed and then produced. CBM formations are often in communication with an aquifer. As a consequence, it is likely that gas production from CBM reservoirs will result in encroachment of water from the associated aquifer. This additional water must subsequently be pumped to the surface along with the desired methane. A successful production strategy that reduces water production and increases the methane production will depend on a variety of factors including cleat spacing, aquifer strength, efficient dewatering technique and sorption characteristics (Sawyer et al., 1987).

The initial stage of the CBM production is the dewatering process. However, inefficient production may cause the damage and change in coal seams properties, which in turn will reduce the methane production. Thus, water production becomes one of the key factors to optimize the methane production from CBM reservoirs. Designing of water withdrawal rate thus becomes an important criterion for efficient recovery of gas. In this investigation, the dewatering is modeled as a function of water level which will help in optimizing the rate and designing of artificial lift that is required in the future to produce methane at the depletion stage.

Most of the promising CBM fields in India are lying in the Gondowana basin, specifically Jharia and Raniganj coal fields (Geological Survey of India, 1994); the present study area belongs to this field. Though, a number of investigations have been reported on the geological aspects of these (Sastry et al., 1977), detailed study on reservoir characterization or production aspect is yet to be carried out.

The present paper discussed the dewatering technique of the CBM wells and optimization of water production rate for efficient and effective production of methane from coal beds, which not only optimizes the methane production but can also predict the performance of the wells of the basin. In general, water productivity of CBM wells is determined using type curve analysis

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http://dx.doi.org/10.1016/j.petrol.2013.02.006

Nomenclature

P.I.	productivity index
Q	liquid flow rate, m^3/day if not mentioned otherwise
P_{ws}	static bottom hole pressure
P_{wf}	flowing bottom hole pressure, psi
Q_w	water flow rate at the surface conditions, m^3/day
$P_{dynamic}$	bottom hole flowing water pressure, psi
P_{static}	shut in water pressure, psi
$WL_{dyanmic}$, $L_{dyanmic}$	dynamic water level in the well, m
WL_{static}	static water level, m
C, $C1$, n, $n1$	constant derived from the test plots

(Aminian et al., 2005), which is time consuming and required a number of data. Hence, simplified mathematical correlations have been proposed and developed for the wells to predict water production rate from the known water level or vice-versa.

2. Methods

2.1. Geology of the Raniganj basin, the study area

Most of the CBM reserve in India is confined mainly to Raniganj and Jharia coalfields. So the study area, Raniganj, is chosen from this region. The region is under the Gandowana basin. Origin and deposition history of the coal are discussed here because these parameters play important roles in gas content and other properties of coal (Chandra, 1992). The Raniganj Basin has a semi-elliptical, elongated shape, and covers an area of 3000 km^2 between the Damodar and Ajoy rivers (Ghosh, 2002). Raniganj Coalfield (Fig. 1) in West Bengal is the largest coalfield in India and comprises a total area of nearly 1260 km^2 (Coal Map, 1993). Raniganj basin is the most prolific for CBM reserve. The evolution of the Gondwana basin was initiated almost at the beginning time period of Gondwana sedimentation, with the tectonic impulses generated by Permo-Triassic (Hercynian) orogeny (Pareek, 2004). Sediments in the Raniganj basin commenced with the deposition of glacial, peri-glacial sediments of Talchir formation. The litho-stratigraphic sequences that are demonstrated in Fig. 1 can provide the idea of the different formations present in the sub-surface. This is also helpful in identification of the coal seams present in the sub-surface. A subsequent idea of the gas and other properties of coal can also be generated with the idea of the formations. The Raniganj coalfield is elongated in an east–west direction following the trend of Damodar valley basins. The coal seams of the Raniganj Formation in the Raniganj Coalfield area have a unique development pattern over a wide stretch. Synthesis of the large volume of data generated from the spurt in exploration activities during the post-nationalization period suggests complex multi-directional splitting and merging tendencies of the coal seam.

The Raniganj Basin is one of the few coal fields of peninsular India where both the Lower Gondwana (Permian) and Upper Gondwana (Triassic–lower Cretaceous) formations are present. The generalized stratigraphy is given in Table 1 (Chandra, 1992; Ghosh et al., 1996).

2.2. Designing of well-testing in CBM wells

Performance prediction tests are run routinely to measure oil, gas and water produced by a particular well under normal producing conditions. From the standpoint of well and reservoir operation, they provide periodic physical evidence of well conditions and unexpected changes if there is any. It is worth mentioning here that coal beds are very much fragile; rubbles and fines are formed during drilling as well as fracturing. These fines generally block the paths of water and gas to flow to the well if proper precaution is not taken. This can drastically reduce the water and gas production rate. Specially designed drilling fluid and fracturing fluids are used to prevent formation damage. Generally underbalanced drilling technology is adopted for drilling of coal bed. Application of light weight foam fluid which can take out the fines from fractures solves this problem.

2.2.1. Conventional wells

For oil wells, results are usually reported as oil production rate. The test equipments consist of (i) a gas oil separator, (ii) a stock tank, with appropriate measuring devices such as (iii) an orifice meter for gas (iv) a hand tape for oil and water, and (v) down hole

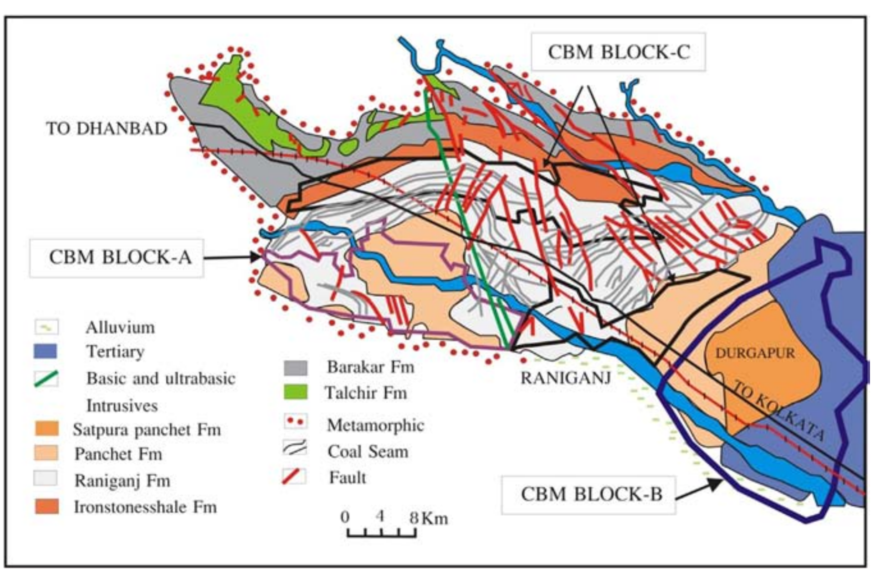

Fig. 1. Geological map of Raniganj coal field.