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Production Performance Analysis for a Coalbed Methane well

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Summary

Coalbed Methane (CBM) is a form of natural gas extracted from coal beds. In recent decades it has become an important source of energy in many countries. The term refers to methane adsorbed into the solid matrix of the coal. CBM reservoir is distinct from typical sandstone or other conventional gas reservoir, as the methane is stored within the coal by a process called adsorption. In this paper, the effect of various petro-physical parameters like porosity and permeability on CBM production has been estimated. It has been noticed that the production trend behaves differently for increasing porosity with constant permeability and increasing permeability with constant porosity. While the permeability increase enhances the rate of production and advances the time of start of production, the porosity increase delays the time of start of production while keeping the rate of production more or less similar.

Introduction

CBM gas reservoirs have gained increasing attention since the last decades in India. These reservoirs are characterized as naturally fractured, shallow, low pressure and water saturated reservoirs. The natural fracture network in coalbeds is essentially formed from cleats. Initially the water, gas and coal are at equilibrium with each other (Jahediesfanjan i and Civan, 2005). The major part of the methane is usually adsorbed over the pore surfaces available in the coal matrix. Hence cleats and fractures are saturated with water at the initial reservoir condition. Consequently, gas production from a CBM reservoir requires dewatering of the reservoir so that the adsorbed gas can be released from the coal matrix into the fractured network.

In the past few years, several models/numerical simulations have been developed that can more realistically represent the production behavior of CBM wells subject to the various conditions like formation damage on fractured reservoir, development of production type curves, consideration of matrix shrinkage and gas slippage effects, CO_2 sequestration, different stimulation techniques and fracture fluid design consideration etc. (Clarkson and McGovern, 2005; Jahediesfanjani and Civan, 2005; Wei et al., 2007 and Zheng and Xue, 2011).

Permeability and gas content are two important parameters dictating the economic viability of CBM reservoir. Well performance is a key factor determining the economic viability of CBM reservoir. Accurate prediction of well performance is required for development strategies such as optimized well spacing, completion gathering system, and well-site design (Clarkson and McGovern, 2005). Main objective of our paper is to analyze the production performance models of a CBM well varying the initial reservoir properties such as porosity and permeability.

Model Setup

Production curves are obtained for the following models

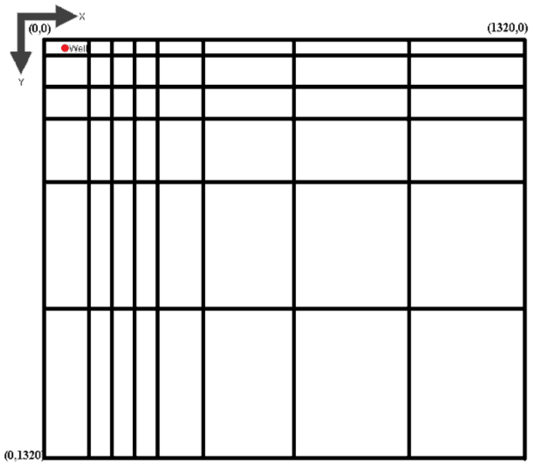

Fig 1(a): Displays a CBM well location and gridding in Plan view

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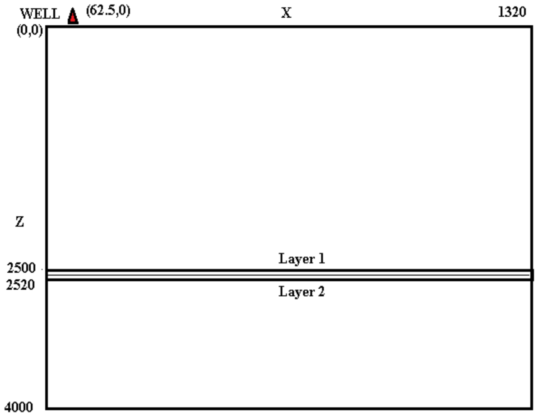

Fig 1(b): Displays coal layer 1 and layer 2 at 2500 ft and 2510 ft respectively in Depth view

corresponding to a well located in a Damodar valley coalfield. Modeling has been carried out with COMET 3 CBM simulation software. The production performance of a single vertically fractured well penetrating two major coal seams (Figure 1) has been analyzed for varying coalbed porosity and permeability for a period of 10 years. In itial porosity and permeability have been used in this modeling as estimated from well log and well test data respectively.

For the modeling purposes the Langmuir pressure and Langmuir volume for coal layers 1 and 2 have been assumed as:

Layer 1:
Langmuir Pressure: 437 psia Langmuir Volume: 15.5 scf
Depth: 2500 ft
Thickness: 10 ft

Layer 2:
Langmuir Pressure: 445 psia Langmuir Volume: 18.7 scf
Depth: 2510 ft
Thickness: 10 ft

Input Parameters and Production Curves

Table 1 lists the input reservoir parameters, time of start of gas production and the peak time period of maximum gas flow. The coalbed porosity and permeability varies from 1 to 2.5% and 0.5 to 3 md respectively. Production curves are obtained for six cases with varying porosity and permeability (Figures 2 to 7). The production curves indicated that at constant porosity (1%) and higher permeability reservoir conditions gas production starts earlier with increasing gas production rates for increasing permeability. Figure 4 shows 180 MSCFD maximum gas productions from a CBM well penetrating the reservoir of porosity 1% and permeability 3 md, whereas maximum production rate is only about 30 MSCFD with reservoir permeability of 0.5 md as in Figure 2. Thus it is evident that the gas production rate is minimal with minimum permeability. It is observed from the production curves that if permeability is relatively more (3 md) even though porosity is assumed at a low value of 1%, the maximum gas production (160-180 MSCFD) occurred during 300-650 days. At a constant permeability of 0.5 md, the porosity is varied to notice the effect on the production curves. It is noticed that with increase of porosity, start of gas production is delayed and the nature of the production curve is flattened as shown (Figures 5 to 7). This is because the water content in the reservoir increases with increasing porosity and it pushes back the start of gas production. The maximum production rate remains more or less between 20-30 MSCFD irrespective of the porosity of the reservoir as the permeability is kept at a constant value.

Conclusions

The production of CBM needs much optimization and refinement due to the unique reservoir conditions that are characteristic of all such energy resources. Highly varyin g porosity and permeability affect the production of gas from these reservoirs and a detailed study of the change in production rate and capacity is required for identifying and predicting the expected production of the reservoirs in the future. The paper attempts to illu strate the effect of change in the production curves with time considering a range of reservoir parameters. The change in permeability with constant porosity greatly affects the production rates by higher rates of production starting early w ith increasing permeability. On the other hand, the change in porosity with constant permeability doesn't affect the production rates to a large extent but delays the start of production from the field due to the large amount of water stored in the pores which must come out before the gas can be released from its adsorbed state.

References

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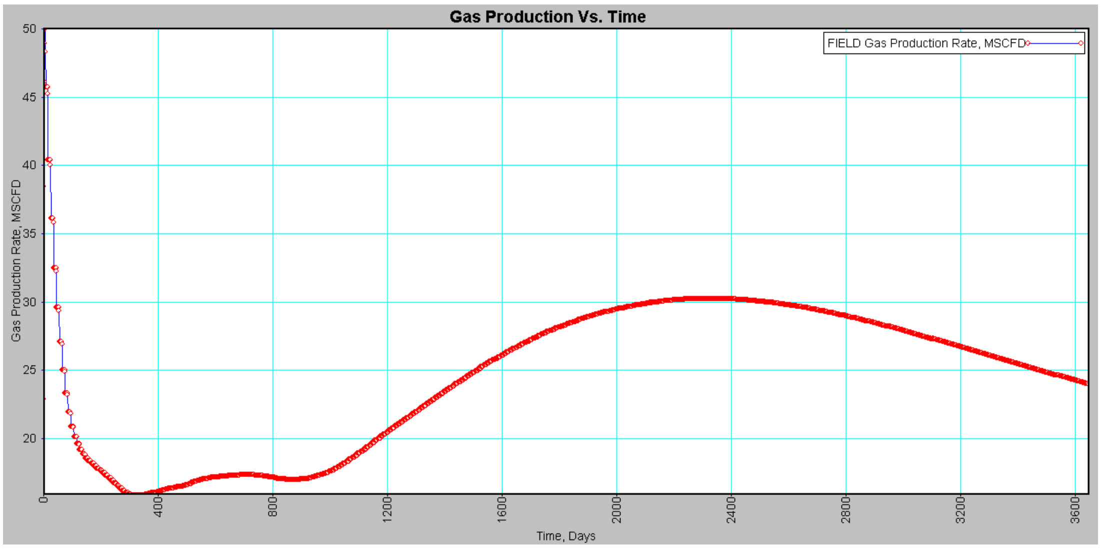

Fig 2: CBM production curve for porosity 1% and permeability 0.5 md

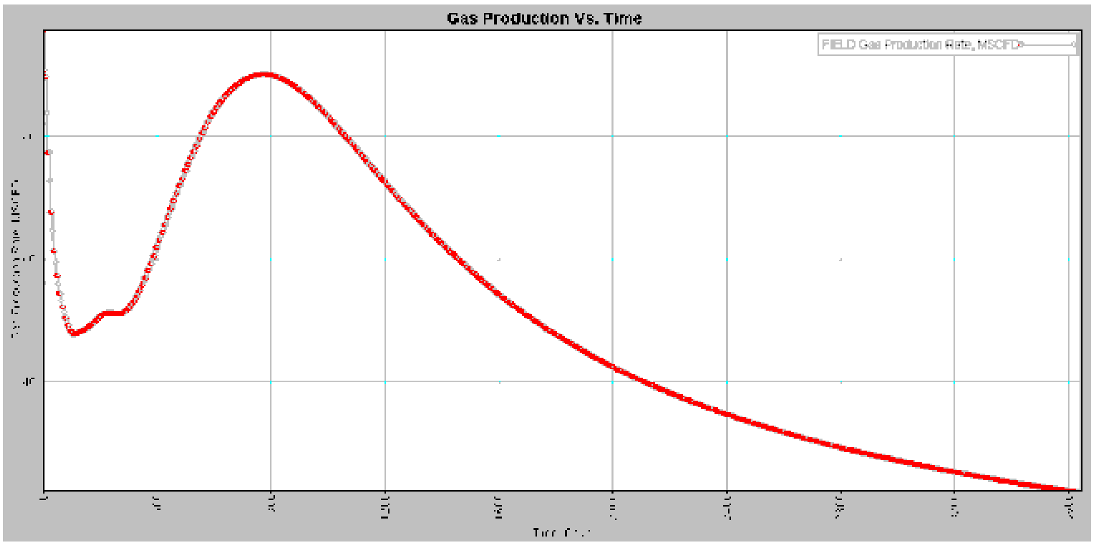

Fig 3: CBM production curve for porosity 1% and permeability 1.5 md.

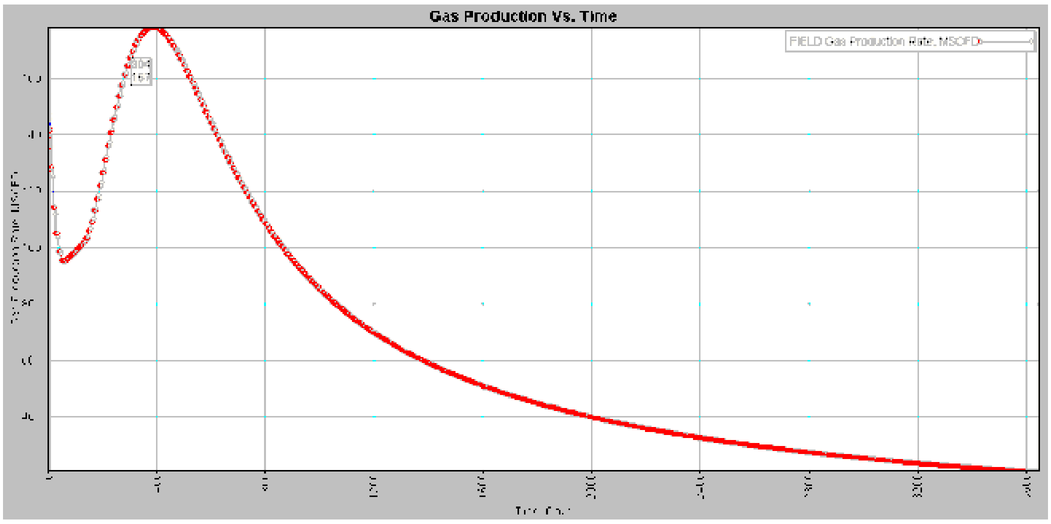

Fig 4: CBM production curve for porosity 1% and permeability 3 md.

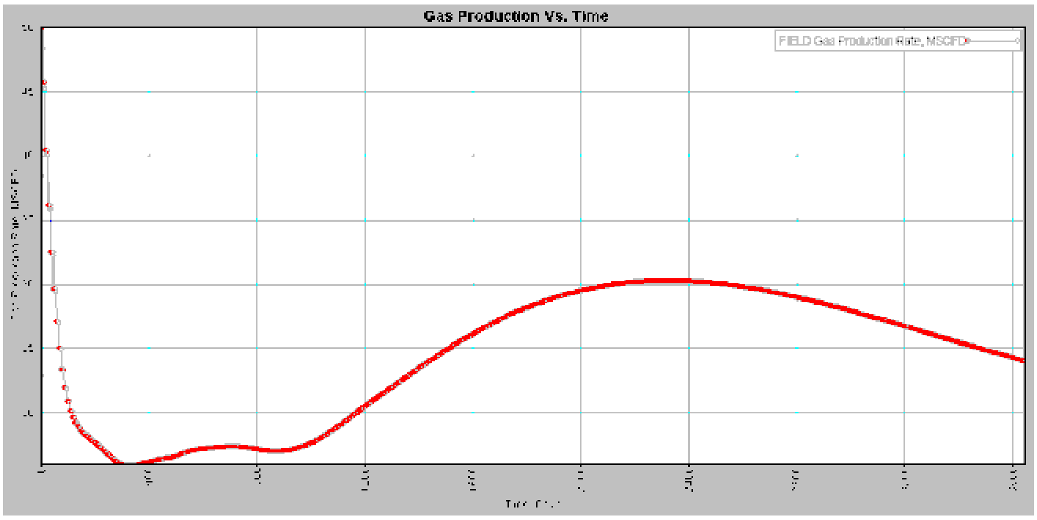

Fig 5: CBM production curve for porosity 1% and permeability 0.5 md.

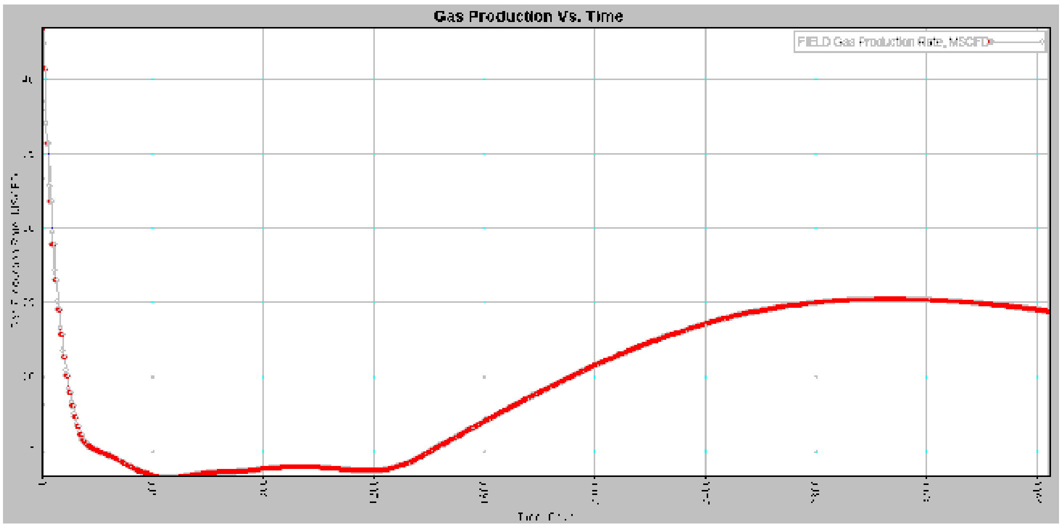

Fig 6: CBM production curve for porosity 1.5% and permeability 0.5 md.

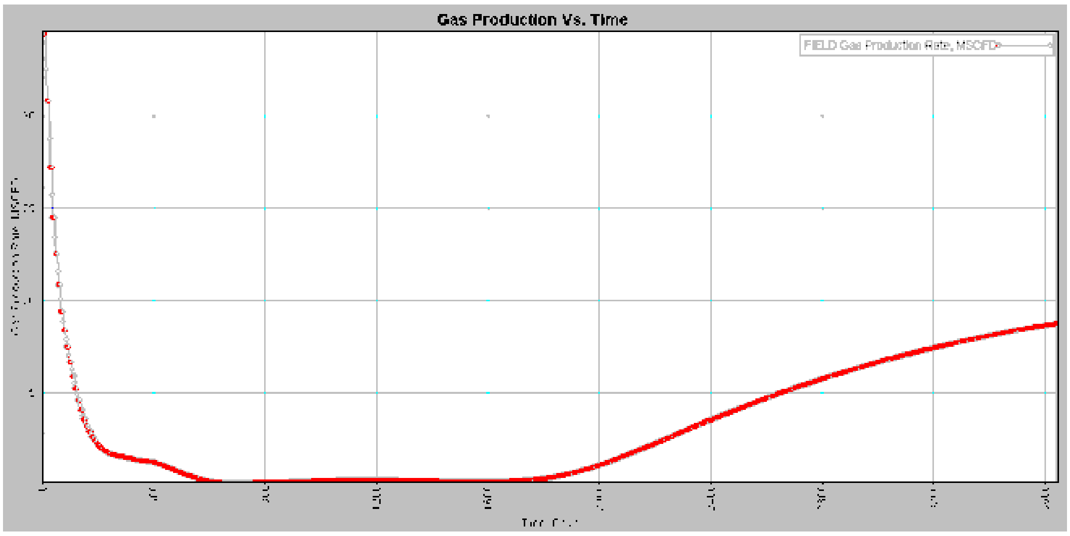

Fig 7: CBM production curve for porosity 2.5% and permeability 0.5 md.

Table 1: Production Performance of a CBM well with varying initial reservoir parameters

Porosity (%)	Permeability (md)	Start of Gas production (Day)	Peak time period (Day)	Maximum Gas Production (MSCFD)
1	0.5	700	1800-3000	28-30
1	1.5	300	550-1050	80-90
1	3	150	300-650	160-180
1	0.5	700	1800-3000	28-30
1.5	0.5	1300	2400-3650	23-24
2.5	0.5	1800	3000-3650	20