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Research Paper

NATURAL GAS RECOVERY: A CASE STUDY OF FIELD SCALE DEVELOPMENT IN RANIGANJ COAL FIELD WEST BENGAL, INDIA

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In this present study coal samples were collected from Upper coal seams located in Sitarampur block of Raniganj coal field. The coal samples were first degasified to estimate the in-situ gas content of samples. The adsorption isotherm study was also done for finding gas adsorption capacity of coal samples. OGIP was determined by standard methods. On the basis of above data reservoir simulation studies were performed, which shows that 9.67 MCM and 2.41 MCM gas recoveries can be possible from seam-I and seam-II. It was seen that 75% more gas recovery can be possible from seam-I with compared to seam-II. So Seam-I is more feasible for gas recovery in this block.

Keywords: Sitarampur block, In-situ gas content, Adsorption isotherm, Reservoir simulation, Gas recovery

INTRODUCTION

Coal bed methane is a form of pure natural gas which is formed during coalification process and its quantity is varies with maturity of coal. The maturity of coal depends on temperature and time on the qualification process which is increasing with depth (Laxminarayana *et al.*, 1999). Most of the gas is escaping into the atmosphere due to the poor retention capacity of coal and less depth of burial (Gayer *et al.*, 1999). Thermogenic gas occurs in sub bituminous through low volatile bituminous and high rank coals due to the ground heat, which is increasing with depth of burial (Scott, 1993; and Scott *et al.*, 1994). Past few decades, Methane emission are significantly increased in the atmosphere due to the enhancement of coal mining activity. Methane is a significant greenhouse gas, which is responsible for climate changes and has a global warming potential 23 times greater than carbon dioxide over 100 years (IPCC, 2001). The recent study involves collection of coal samples from the upper coal seam of a bore hole located in Sitarampur block of Raniganj coal field, India. The unique techniques have been used in the field is a comparison between vertical fracture and

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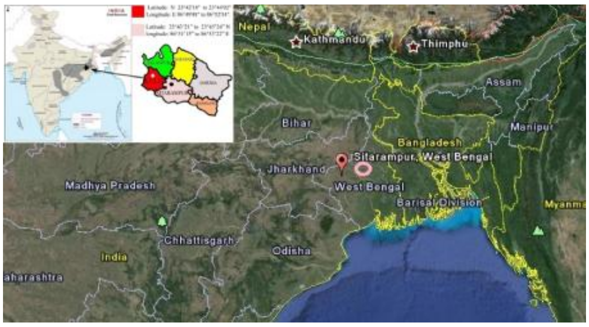
horizontal well for gas production. Feasibility or economy of gas production depends on hydrocarbon recovery from the reservoir. The reservoir modelling and simulation study were carried out by COMET3 simulator.

Geology of Field

The Sitarampur Coal Block covering an area of about 9.00 Sq.km is situated in the western part of the Raniganj coalfield in Burdwan District, West Bengal, India. It is bounded by the coordinates Latitude N 23° 43' 25'' to N 23° 45' 28.11'' and Longitude E 86° 51' 23" to E 86° 53' 28.16". There is a 700 m common boundary with Kulti block in the south west of the block. The structure of Raniganj coalfield is comparatively simple with regional dip towards the south in the major part of the area. The dip of strata varies from 5° to 10° from north to south. The strike of the formation in Sitarampur Coal Block is almost NE-SW. Altogether 14 faults have been reported, all of which are more or less strike to oblique faults. The throw of the faults varies from 0 to 240 m. In general the trend of the fault is WSW-ENE. No mining activity is reported from the block. The location of block is shown in Figure 1.

Figure 1: The Location of Sitarampur Block



MATERIALS AND METHOD

Model Setup: The 3-D reservoir model represented by a 254.6*254.6*10 Cartesian grid pattern of 11*11 m mesh geometry was the integral structure for the coal seam characterized through a dual porosity the simulation model constructed in COMET3. Seam wise gas content, permeability, Adsorption isotherm data, porosity, permeability and hydrostatic reservoir pressure was input for Simulation study shown in Table 1.

Gas Content Estimation: Canister desorption experiments were employed for determining gas desorption rate and gas content of the coal samples. The in-situ gas content in the coal were estimated by adding lost, measured and residual gas volumes divided by mass of coal sample. The desorption study is performed by sealing coal sample in a canister and measuring the volume of gas evolved from the sample as a function of temperature, time and pressure. The volume of gas which is released from the coal sample is measured by displacement of water from a graduated cylinder.

Adsorption Isotherm Estimation: The adsorption isotherm study of coal samples was done in the laboratory by adsorption apparatus. The experimental setup used for the volumetric adsorption isotherm consists of water bath which is used to maintain desorption isotherm conditions for the reference and sample bombs, the control panel employed for regulating the flow of gas to the reference and sample cells with monitoring gas pressure. The reference cells are never separated from the system and its purpose is to store a known volume of gas at known pressure and temperature. Sample cells are used to keep the coal samples to determine adsorption isotherm. Estimation of the isotherm involves two step first is to determination of dead volume of the system and second evaluation of adsorption isotherm. First, the samples were prepared in the

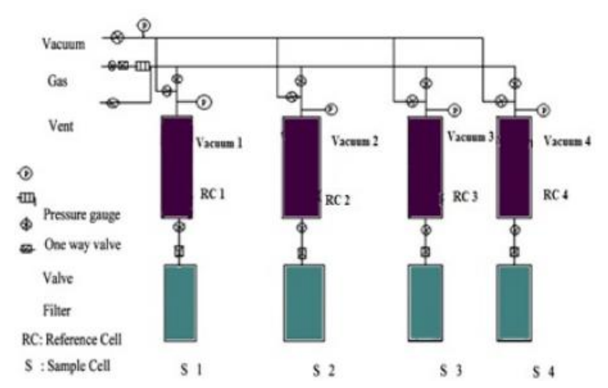
Table 1: Average Properties of Coal Samples

Parameter	Seam-I	Seam-II
Depth of reservoir, m	860.3	1097.7
Reservoir temperature, ^{0}F	140.556	142.727
Reservoir pressure, psi	957.957	1222.84
Porosity, %	0.005	0.005
Permeability, mD	5.43527	4.055
Coal density, gm/cc	1.35	1.38
Thickness Seam (m)	2.3	2.35

standard size range and then for equilibrated moisture by following ASTM standard. A known sample weight is put into the sample cell, then attached to the apparatus. The dead volume is then determined by evacuating and filling the reference cell with helium and allowing it to equilibrate. The helium is then admitted into the sample cell and dead volume is calculated by the drop in pressure.

After determination of the dead volume, the apparatus is again evacuated for determination of adsorption isotherm. The adsorbent is added to the reference cell, allowed to equilibrate and then admitted into the sample cell. The amount of gas adsorbed is determined from drop in pressure. The procedure is repeated at increasing pressure steps until the high pressure is reached. Schematic diagram of adsorption system is presented in Figure 2.

Figure 2: Schematic Diagram of Adsorption System



Coal Quality Analysis: The proximate analysis was used to find the coal quality in the block. The analysis of coal for that sample were crushed, and sieved through 72-BSS mess openings. Proximate analyses of the sample were done by using muffle furnace as per the standard method. The result of proximate analyses is shown in Table 2.

RESULTS AND DISCUSSION

Gas Content: The desorption study was carried out to find lost, desorbed and residual gas as discusses above. The gas content study was carried out at Standard Temperature and Pressure (STP). The gas content value of coal samples various from 10.00 to 14.06 cc/gm on as receive basis to dry ash free basis. The lost gas contents of the sample has been found in the range of 0.31 to 0.43 cc/gm at STP on as receive basis to dry ash free basis.

The Residual gas of the coal samples of the study area varies from 0.29-0.42 cc/gm at STP on as receive basis to dry ash free basis. The coal samples category belong to sub-bituminous to bituminous coal. The gas content value of coal samples was shown in Table 3.

Original Gas in Place: The thicknesses of the collected coal samples were 2.30 m with a

Table 2: The Estimated Gas Content of the Sample

Seam No.	Wt. (gm)	Q_1 (cc/gm)	Q_2 (cc/gm)	Q_3 (cc/gm)	p¦Q (cc/gm)
Dry ash as free basis	1070	0.42	13.21	0.42	14.06
As receive basis	1070	0.31	9.4	0.29	10

Table 3: Proximate Analysis of Coal Samples

Seam	Moisture (%)	Ash (%)	VM (%)	FC (%)
I	1.37	22.16	20.55	55.92
II	1.28	26.25	20.45	52.02
III	1.24	31.26	19.08	48.42
IV	1.23	19.93	18.91	59.93
V	1.14	18.69	18.33	61.84

density of 1.35. The Estimation of gas resource was done from Equation (1) given below:

$$OGIP = \text{Coal zone thickness} \times \text{Area} \times \text{Density} \times G_t \quad \ldots(1)$$

The thickness of the first coal seam was 2.30 m with gas content 14.06 cc/g and 80 acre area, estimated reserve was 14.14 MCM.

Adsorption Isotherm Study: The Langmuir volume shows the gas storage capacity of the coal sample at infinite pressure, and Langmuir pressure is the pressure at which the gas storage capacity of the coal sample is half the Langmuir volume. The gas storage capacity of coal samples increases non-linearly as pressure increases and decreases with an increase in the temperature, moisture and ash content. From experiments, it was seen that the coal is having the higher adsorption capacity. The values are varying from 16.2-22.7 cc/gm at moisture equilibrated and dry ash free basis. The actual gas present in the sample is low which may be due to escape of gases through faults or fractures. The methane adsorption isotherm curve for the coal sample is shown in Figures 3 and 4. Similarly the Langmuir constant curves for both of coal samples are shown in Figures 5 and 6.

Simulation Results: The simulation study which was carried out by using COMET3 software. The input data for this study are initial pressure, in-situ gas content, Langmuir volume, Langmuir pressure and some reservoir parameters, the following result was obtained from the simulation study. Since the gas recovery from both of the reservoir were very less so fracture well approach is used for enhancing permeability of the coal bed. The simulation study shows that the recovery factor 68.45% and 42.16% can be achieved with a recoverable resource of 9.67MCM and 2.41MCM by fractured well approach. The predicted future cumulative, production rate of the recoverable gas and water has been shown in

Figure 3: Methane Adsorption Isotherm Curve of Seam-I

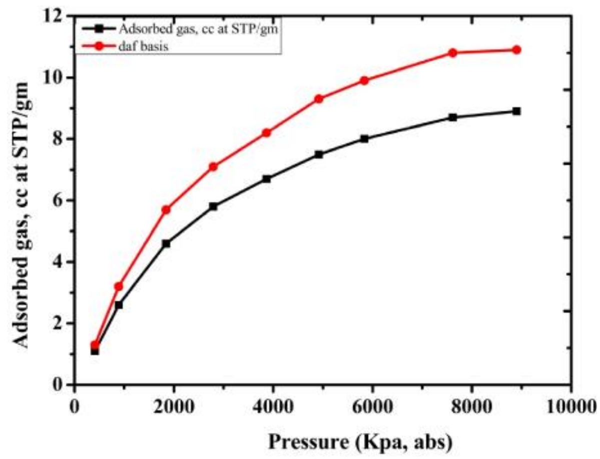


Figure 4: Langmuir Constant Curve for Seam-I

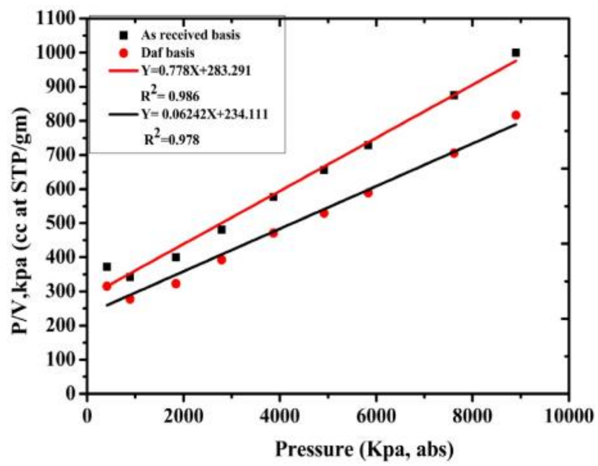


Figure 5: Methane Adsorption Isotherm Curve of Seam-II

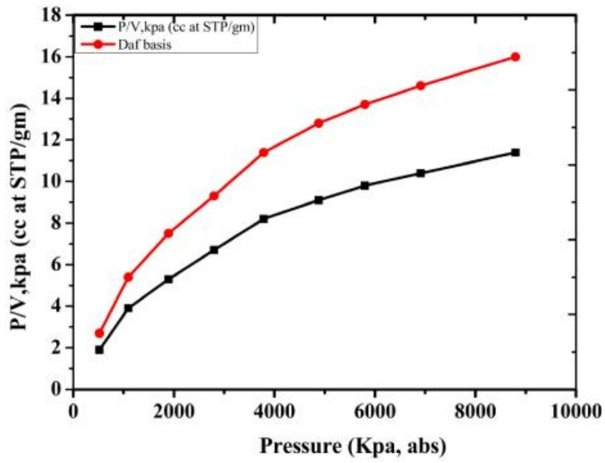
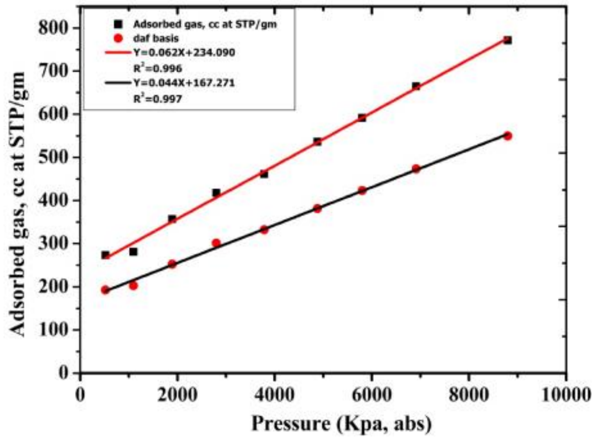


Figure 6: Langmuir Constant Curves for Seam-II



Figures 7 and 8 for seam-I. Similarly cumulative, production rate of the recoverable water and gas production have been forecasted in Figures 9 and 10 for seam-II. The results show that little depressurizing is needed to start gas production from the reservoir under study. It is necessary to decline the reservoir pressure to a desorption pressure of gas so that the gas would start to desorb from the coal seam.

Figure 7: Cumulative Gas and Water Production with Time for Seam-I

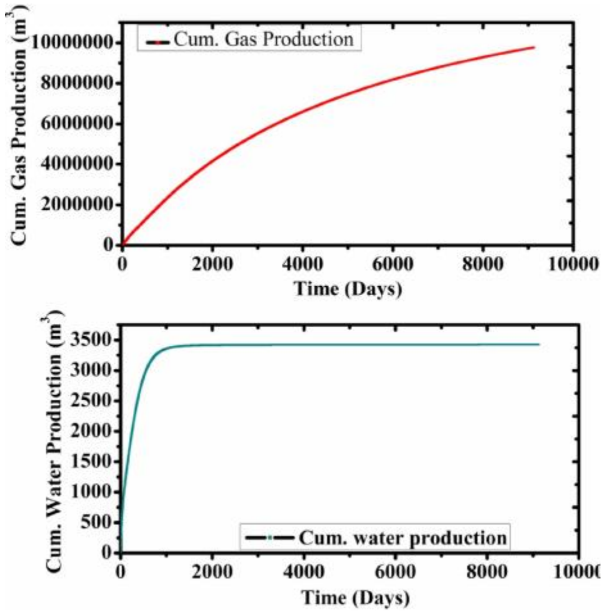
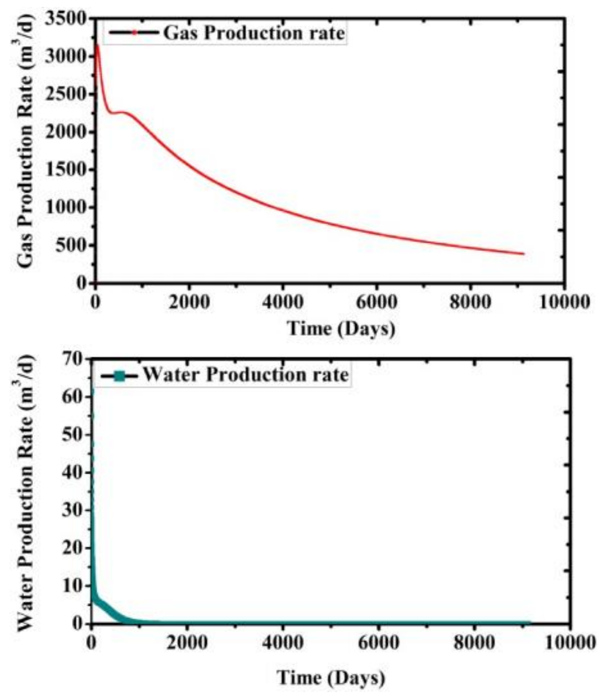


Figure 8: Gas and Water Production Rate with Time for Seam-I



Coal and Gas Resource in Sitarampur Coal Block

The average gas content of coal seams was then computed. Seam-wise coal reserves were also estimated using coal seams thickness and block area. Gas reserves were then computed by

Figure 9: Cumulative Gas and Water Production with Time for Seam-II

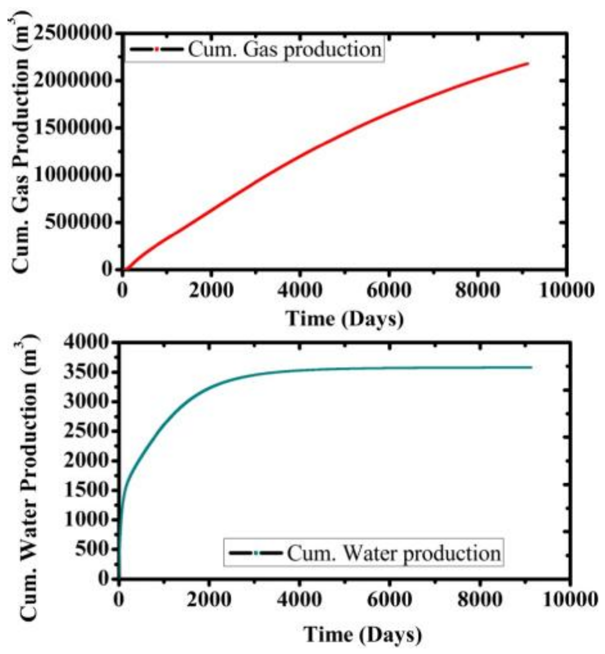
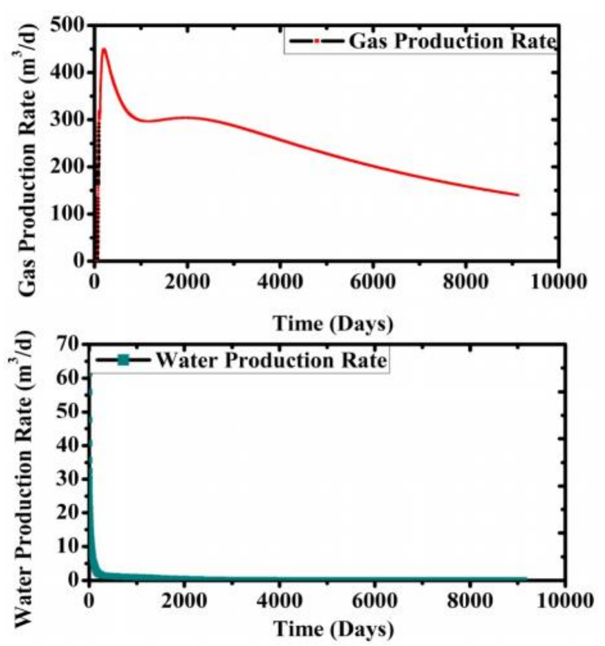


Figure 10: Gas and Water Production Rate with Time for Seam-II



multiplying the coal reserves and average gas content. Seam-wise coal reserve, their average gas content and estimated gas resource are summarized in Table 4.

Table 4: Coal Reserve, Average Gas Content and Gas Resource in Sitarampur Block

Seam	Coal Reserve (Mt)	Average Gas Content (m^3/t)	Gas Resource (MCM)
I	20.83	1.4	29.16
II	15.97	5.74	91.66
III	16.66	6.22	103.62
IV	32.24	8.9	286.93
V	124.93	8.98	1121.87
Total	210.63		1633.24

The Sitarampur block is having a good potential for mining of high quality coal as the available data indicate consistency. There is a considerable amount of gas resource as well. Total gas resource in Sitarampur Block is estimated as 1.63 BCM.

CONCLUSION

The study was carried out for both of reservoirs with a fracture coal bed.The gas and water recovery is improved in case of fracture coal seam. The estimated resource which recovered from seam-I and seam-II is around 9.67 MCM and 2.41 MCM. It was seen that 75% more gas recovery can be possible from seam-I with compared to seam-II. So Seam-I is more feasible for gas recovery in this block. The adsorption capacities of coal seams are good enough for gas production. The simulation study suggests that recoverable gas content is low and needs to depressurize before production. The successes in gas recovery can be possible in the block by advanced technology like enhanced recovery techniques to fulfil energy demand of our country.

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