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Technical Challenges and Solutions of Produced Waters from Coal Bed Methane [CBM] Reservoirs

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Summary

Technological progress in the oil and gas industry is an incremental process involving consistent investment and the application of scientific, engineering and managerial expertise over sustained periods of time. Efficient and reliable energy supplies are essential for accelerating the growth of Indian economy. In this context, Coal Bed Methane (CBM) can play a major role in reducing the share of import content and augment the overall energy supply in the country. Conventional analysis methods are used with varying success to describe coal bed methane reservoirs. This paper discusses few techniques that have been developed specifically to address the key challenges — namely, which seams contain the most gas and how to manage the water produced from it. This helps the oil and gas operators to optimize the field utilities and on the other hand gains profit from the produced waters from the coal bed methane reservoirs.

Introduction

Coal-bed methane (CBM) is an economic source of pipeline-quality methane that is generated and stored in coal beds. It is an unconventional gas resource that consists of methane production from the coal seams. The key parameters for the evaluation of coalbed methane (CBM) prospects are the gas resources, reserves and deliverability. Coalbed methane reservoirs are dual-porosity media where the vast majority of the gas is stored in the low permeability coal matrix (primary porosity) by sorption. The flow to production wells, however, occurs through the coals natural fracture system (secondary porosity), which stores relatively small amounts of gas, because coal matrix practically has no permeability.

Producers must depressurize a reservoir via water production to desorb gas from coal. Reservoir pressure must be reduced below the effective partial pressure of methane (critical desorption pressure) to allow two-phase flow of gas and water, allowing methane to flow from its adsorbed state in the coal to gas phase and into the well bore. The water production declines rapidly until the gas rate attains a peak value and water saturation approaches the irreducible water saturation i.e., reaches connate water saturation. Once the peak gas rate is attained, CBM reservoirs act like a conventional reservoir. So it is very critical for oil and gas operators to control the water problem in coal bed methane reservoirs to resume production.

Theory:

Coal-bed methane production started as a way to keep coal mining safe from explosions. Not only does it provide the same service now, it also decreases emissions of greenhouse gasses from mines, decreases air pollution because it is a clean-burning fuel, decreases the need for "conventional" fossil fuels, and further utilizes the vast coal resources that are already known. Methane gas is generated during the formation of coal through coalification process of vegetal matter. This can broadly be divided into biochemical and physico-chemical stages of coalification incorporating five successive steps. The five steps are Peatification, Humification, Bituminization, Debituminization and Graphitization. Many physical and chemical changes, governed by biological and geological factors, occur during these processes. Whereas darkening in color and increase in hardness and compactness are the main physical changes, loss in moisture and volatile contents, and increase in carbon content are the main chemical changes. Many acids (humic, fatty, tannin, gallic, etc.) and dry and wet gases (CH_4, CO_2, N_2, N_2O, H_2S, ethane, propane, butane, etc.) are formed during decomposition of the organic matter.

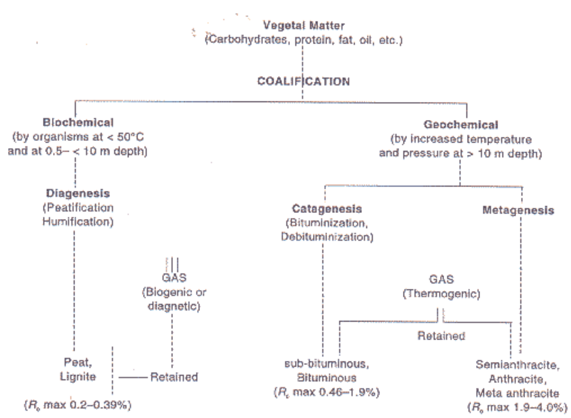

Figure 1: This shows the formation of biogenic and thermogenic gasses from vegetal matter with time.

Global Distribution of CBM:

CBM a source of clean energy is being commercially exploited and used around the world for the last one and half decades. The leading country in its commercial exploitation is USA.

CBM development was started in USA in the early '80s when production of CBM was 10 BCF (Billion Cubic Feet) 1984 and by 1990 the production had reached to a level of 194 BCF. The present CBM production is over 1200 BCF per year.

India is endowed with rich deposits of coal and lignite in different sedimentary basins of varying dimensions. The bulk of the coal resource of 241 billion tones is contained in older basins. Large lignite deposits of 100 billion tones occur in younger basins of Gujarat, Rajasthan (Western India) and Tamil Nadu (Southern India). A characteristic feature of these basins is the development of very thick coal and lignite seams (20-80m) over a large stretch of the coal/lignite fields. In fact one of the thickest seams (138m) of the world known is from the Indian coal field. This resource base provided impetus for spurt in coal mining activity and India now holds fourth position in coal production in the world with output of more than 300 million tones per annum. India is having sixth largest proved coal reserves in the world. India holds significant prospects for commercial exploitation of CBM. Coal accounts for 97% of the fossil energy resources in India and about 70% of the coal produced in India has been used for thermal power generation.

India with total coal reserves of 241 billion tones as on 01.01.2002 also has a great potential of CBM development. However due to the technological breakthrough from development of CBM in USA the exploitation of CBM in India seems to be a very promising future. Based on the general information of the geological and gas content of the seams in various coal fields in India, the estimates of CBM reserves are around 2 TCM. Large resources of high rank coal in the country provide ample opportunities for harnessing this source of non-conventional gas.

Country	Coal Resources (10^9 tonnes)	CBM Resources	
		TCF	TCM
For USSR	4405	600-4000	17.0-114.25
China	1566	1115	31.8
USA	1570	420	12.0
Australia	785	380	10.8
Canada	63	360	10.2
India	200-241	30-53	0.85-2
Indonesia	17	213	6.08
Africa	129	115	3.2
U.K	190	100	2.8
Poland	184	100	2.8
Germany	285	100	2.8
Zimbabwe	8	1.75	0.05

Table 1: This shows the global distribution CBM resouces from the available coal reserves (WEC).

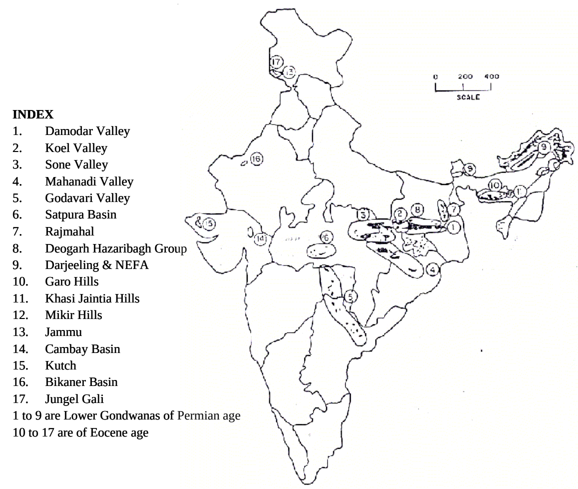

Figure 2: This figure shows the Coal Bed Methane Productive areas in India.

Challenges:

Ground water movement is considered critical parameter for evaluating CBM potential of an area. The ground water movements are responsible for transporting methogenic bacteria. These bacteria generate biogenic gas in turn, recharging coal seams with gas, resulting in methane enrichment and high reservoir pressures.

CBM wells produce more water initially when compared to conventional reservoirs. Methane gas is adsorbed to the surface of the coal because of the water-contributed pressure in the coal bed reservoir. Removal of this water by pumping is necessary for same reasons; it helps lower the pressure in the reservoir and it stimulates desorption of methane from the coal.

The water in coal beds contributes to pressure in the reservoir that facilitates methane gas adsorbed to the surface of the coal. The water co-produced with methane is not reinjected into the producing formation to enhance recovery, but is disposed of or treated to remove dissolved sediments before used for beneficial purposes.

Disposal of this large amount of water is complicated as much of the water is of low quality. The main problem with the disposal of well is their cost, ranging from $400,000 to $1,200,000 depending on depth and stimulation type. The total disposal cost for water to bring to the surface will be approximately $1.0 to $4.0 per barrel.

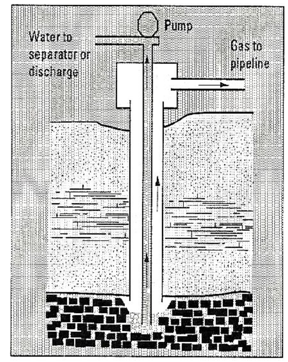

Figure 3: This figure shows the Coal Bed Methane Production from the well and seperation of both gas and water at the surface.

The high capital cost is a restriction for small independent operators. Some of the factors attributed to the disposal costs included pipeline maintenance and repair costs, electrical costs to operate pumps, virtually round-the-clock staffing to operate electrical generators, life of the facility, depth of the injection well, chemical treatments to disinfect water that is reused for livestock.

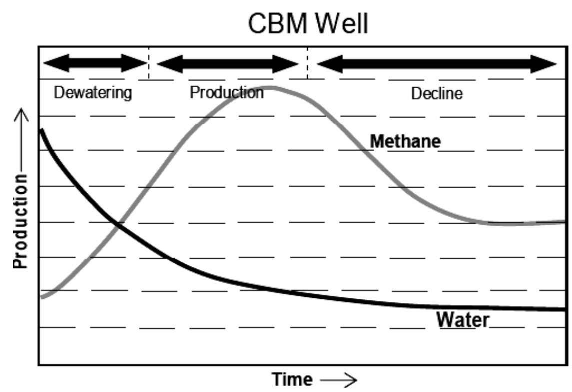

Figure 4: This shows the rate of water production and gas production with time.

Looking at the statistics of water production from the CBM reservoirs the amount of water produced is very high.

Basin	State	Produced Water	Water Production (Bbl/d/well)
Powder River	Wyo., Mont.	500	400
Raton	Colo. NM	1500	226
San Juan	Colo., NM	8000	25
Unita	Utah	15000	215

Table 2: This table shows the water production in CBM fields of USA. (EIA 2006)

The water produced from the CBM reservoirs is discharged to a pond for evaporation.

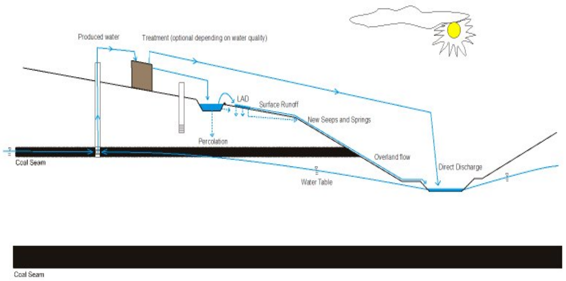

Figure 5: This figure shows the product waters diverted to the pond at the site for evaporation.

The coal bed methane product waters contain a large number of chemicals which are to removed for their daily use a irrigation of sensitive crops, to be applicable to vulnerable soils, unrestricted beneficial discharge to surface waters and use of an otherwise wasted resource - groundwater.

Chemical Composition	Amount present in Feed
pH	8.1
EC (dS/m)	4.45
Ca^{2+} (meq/l)	0.9
Mg^{2+} (meq/l)	1.7
Na^{+} (meq/l)	38.3
Cl^{-} (meq/l)	0.6
SO_4^{2-}	1.5
HCO_3^{-} (meq/l)	49.6
SAR	33.6

Table 3: This shows the composition of the product waters from the CBM reservoirs. (Montana)

Due to the above reasons if disposed in the atmosphere the waters create many problems ground water depletion, ground water contamination through the presence of methane in the ground water and degradation of the surface water due to excessive salt content in it.

In general the coalbed methane producibility is dependent as synergistic interplay of fractures such as coal rank, gas content, permeability, hydrodynamics, tectonics and structural setting.

Innovative / Alternate Solutions:

The innovative solutions for efficient treatment or disposal of the produced waters from the CBM reservoirs are as follows.

- Treatment of water using some **coagulants** which have the capacity to coagulate and helps in purification upto considerable ppm levels.

The present study used a test to examine quality improvement of water by direct filtration seed as the coagulant. The goal was to assess suitability of the method for water treatment in rural areas of developing countries.

The technique mainly concentrates on purification systems where they lack proper commercial installment facilities. This mainly focuses on achieving purification using minimum energy resources, which contributes to energy optimization and can meet the environmental norms.

- Reinjection into aquifers depleted by CBM production previously.
- Injection or percolation into depleted aquifers with water treatment as required protecting and/or enhancing water quality.
- Replace other uses where quality allows.
- Surface discharges with water treatment as required resulting in improved stream flows with adequate mitigations against negative impacts.
- Direct discharges that degrade water quality and negatively impact downstream users or result in loss of resource should be treated.
- Evaporation of water resulting in loss of resource which is not recommended.

Recommendations:

The coal seams which are not economically productive can be used to inject the carbon dioxide gas into them and it can be retained there decreasing the green house gas emissions. The carbon dioxide is stored in the underground void-rock matrix and can have the ability of carbon dioxide to chemically bind with coal. But some carbon dioxide injection projects caused swelling of the coal and thus reduced the overall injectivity of the coals. This coal sequestration in the underlying coal seams helps to reduce the emissions and also help in evaluating the economic performance of the methane recovery business.

So as carbon dioxide injection reduces the injectivity of the coal seams, now a day's nitrogen is also used as an injecting medium to enhance the injectivity of coal and allowing the carbon dioxide to bond to coal much deeper into the seam.

Conclusion:

Coal can typically adsorb five times more carbon dioxide than the methane it releases. With massive remaining coal reserves and growing interest in CBM opportunities the Indian coal industry should identify the importance of exploitation of the coal reserves for CBM which would help the operators to gain profits by managing the water production by adopting the above mentioned solutions and can also contribute to the energy security for the country. As this is used for storage of carbon dioxide and other emissions interest has grown in this field which can be used as a location for harmful emissions. Coal, the once valuable energy source which became known as a dirty source of energy, is now poised to supply clean energy and pollution solutions.

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