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CBM and CO_2 Sequestration in India: Solution to India's Growing Energy Needs and Mitigation of Global Warming

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Abstract: To meet the rapidly increasing demand for energy and faster depletion of conventional energy resources, India with other countries is madly searching for alternate resources like coal bed methane, shale gas, gas hydrate. At the same time use of large quantity of fuel emits a huge volume of CO_2 to atmosphere. The present paper discusses about the utilization of coal bed methane (CBM) gas as the clean fuel and feasibility of CO_2 sequestration process to enhance CBM production.

Keywords: CBM, CO_2 Sequestration, Global Warming, Methane recovery, clean energy

1. Introduction

With the nation requiring more energy sources to sustain its rapid pace of development, India is struggling for more and more energy resources. Currently, gas demand exceeds supply by 30 per cent. Coal Bed Methane (CBM) is considered to be one of the most viable alternatives to combat the situation [1].

Coalbed methane is generated during coalification process which gets adsorbed on coal at higher pressure. It is a mining hazard. Presence of CBM in underground mine not only makes mining works difficult and risky, but also makes it costly. Even, its ventilation to atmosphere adds green house gas and therefore contributes to global warming. However, CBM is a remarkably clean fuel when burnt. CBM constitutes clean gases having heating value of approximately 8500 KCal/kg compared to 9000 KCal/kg of natural gas. It is of pipe line quality. Therefore, it can be fed directly to national pipeline grid. Production of methane gas from coalbed would lead to demethanation of coal beds and avoidance of methane emissions into the atmosphere, thus turning an environmental hazard into a clean energy resource.

As the third largest coal producer in the world, India has good prospects for commercial production of coal bed methane. Nevertheless, with demand for gas rising sharply, CBM will have to compete with imported (liquefied) natural gas. Methane is, however, a viable alternative to compressed natural gas (CNG) and its use as automotive fuel will certainly help reducing pollution levels. India is one of the select countries which have undertaken steps through a transparent policy to harness domestic CBM resources. The Government has received an

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overwhelming response from prospective producers with several big players starting operations on exploration and development of CBM in India.

India is set to become the fourth after US, Australia and China in terms of exploration and production of coal bed methane. In order to fully develop India's CBM potential, delineation of prospective CBM blocks is necessary. There are other measures like provision of technical training, promotion of research and development, and transfer of CBM development technologies that can further the growth of the sector. With growing demand and rising oil and gas prices, CBM is definitely a viable alternative supplementary energy source.

However, India lacks in CBM related services which delayed the scheduled production. Efficient production of CBM is becoming a real challenge to the E & P companies due to lack in detailed reservoir characterization. So far, the most investigations have been limited to measurement of adsorption isotherms under static conditions and is deficient in providing information of gas pressure-driven and concentration-driven conditions.

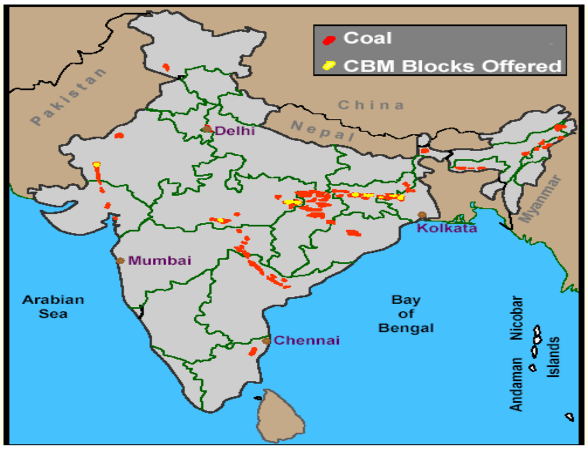

Figure 1: CBM reservoir in India (courtesy: Ministry of Coal, Govt. of India)

More care should be taken on measurement of porosity and permeability also. To produce more methane from the coal enhanced technology like CO_2 sequestration could be used. This process can not only reduce the emission of this gas to atmosphere, will also help in extra production of methane gas [2].

2. Global and Indian Scenario

Estimates of India's CBM potential vary. One source estimates up to 2 trillion m^3 of CBM in 56 coal basins covering 64,000 km^2. The major coal fields and CBM blocks in Indian are shown in Fig 1. The Directorate General of Hydrocarbons [3] of India estimates that deposits in major coal fields (in twelve states of India covering an area of 35,400 km^2) contain 4.6 TCM of CBM [4]. Coal in these basins ranges from high-volatile to low-volatile bituminous with high ash content (10 to 40 percent), and its gas content is between 3-16 m^3/ton (Singh, 2002) depending on the rank of the coal, depth of burial, and geotectonic settings of the basins as estimated by the CMPDI. In the Jharia Coalfield, the gas content is estimated to be between 7.3 and 23.8 m^3 per ton of coal within the depth range of 150m to 1200 m. Analysis indicates every 100-m increase in depth is associated with a 1.3 m^3 increase of methane content [5].

The largest CBM resource bases lie in the former Soviet Union, Canada, China, Australia and the United States. However, much of the world's CBM recovery potential remains untapped. In 2006 it was estimated that of global resources totaling 143 trillion cubic meters, only 1 trillion cubic metres was actually recovered from reserves. This is due to a lack of incentive in some countries to fully exploit the resource base, particularly in parts of the former Soviet Union where conventional natural gas is abundant. The United States has demonstrated a strong drive to utilize its resource base. Exploitation in Canada has been somewhat slower than in the US, but is expected to increase with the development of new exploration and extraction technologies.

The potential for supplementing significant proportions of natural gas supply with CBM is also growing in China, where demand for natural gas is set to outstrip domestic production by 2010 and CBM offers an alternative supply [6].

The main hurdle associated with the production of CBM is the requirement of long dewatering of coal bed before production. This difficulty may be resolved with implementing the CO_2 sequestration technology. Due to higher adsorption affinity of CO_2 to coal surface [7] as shown in Fig 2, methane will be forced to desorp from the coal surface at comparatively high pressure and can reduce the dewatering time and hence the total project period. CO_2 sequestration in coal bed will alleviate the global warming problem to some extent and also will enhance methane production from coal bed simultaneously. Thus this technology will reduce the cost as well as environmental hazards. China, Australia, USA have been started to implement this technology for enhanced recovery of CBM gases. In India, commercial CBM production is yet to be started. ONGC and Essar Oil have started pilot scale production, but field development is yet to be completed. ONGC has started multilateral drilling for efficient recovery of methane from some fields.

2.1 Methodology

Production of gas is controlled by a three step process & desorption of gas from the coal matrix, diffusion to the cleat system, and flow through fractures [8] as shown in Fig 3. Many coal reservoirs are water saturated, and water provides the reservoir pressure that holds gas in the adsorbed state.

Flow of coalbed methane involves movement of methane molecules along a pressure gradient. The steps include desorption from the micropores, diffusion through the matrix pore structure, and finally fluid (Darcy) flow through the coal fracture (cleat) system. Coal seams have two sets of mode; breaking in tension joints or fractures that run perpendicular to one another. The predominant set, face cleats, is continuous, while the butt cleat often terminates into the face cleats. Cleat systems usually become better developed with increasing rank, and they are typically consistent with local and regional stress fields.

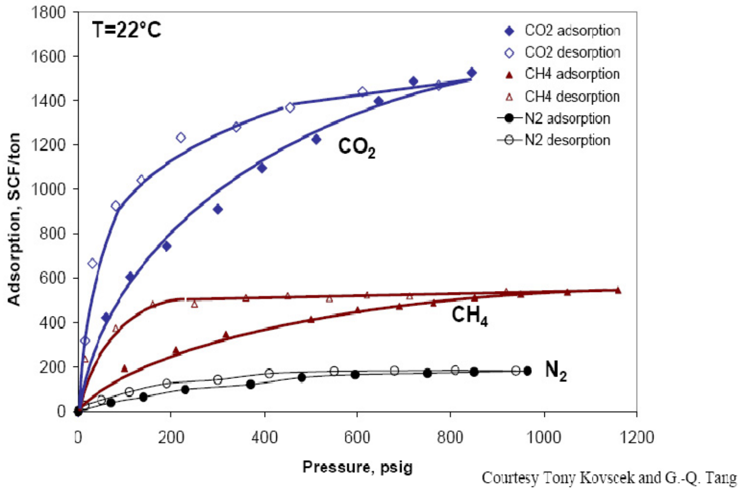

Figure 2: Preferential adsorption of CO_2 over CH_4[7]

The size, spacing, and continuity of the cleat system control the rate of fluid flow once the methane molecules have diffused through the matrix pore structure. These properties of the coal seams vary widely during production as the pressure declines. Coal, being brittle in nature, cannot resist the overburden pressure with reduction in pore pressure during dewatering; and fractures are developed. As a result, the basic petrophysical properties of coal responsible for production of methane, e.g. porosity, permeability vary widely with change in the pore pressure during dewatering as well as gas production period. Hence, efficient production of methane from coal bed needs continuous monitoring of variation in porosity, permeability and compressibility of coal. The unique features of the coal are that coals are extremely friable; i.e., they crumble and break easily. Therefore, it is nearly impossible to recover a "whole" core. Direct measurement of intrusive properties like permeability, porosity, compressibility, relative permeability measurements are very difficult and must rely on indirect measurement.

Moreover, coal is highly compressible (~as high as $2x10^{-3}$ psi^{-1}) [9]. Variation of permeability and well bore properties during production requires accurate well test analysis using correct model. CBM reservoirs are of dual porosity system, which demands for special models of well test analysis. So, only static adsorption-desorption study can not suffice the analysis of coal bed methane production. As these properties will continuously vary during production, efficient & economic production of methane from coal bed requires constant monitoring and analysis of the system by experienced and proficient persons.

3. Conclusions

CBM technology is proceeding with good space to prove itself as a cleaner energy security to India as well as the World. However, production strategy of methane from CBM is very much different from conventional gas reservoir. Sequestration of CO_2 helps in mitigation of global warming, at the same time helps in recovery of methane gas from coal bed unveiled otherwise. However, detailed and intensive studies are required for efficient and economic production of coal bed methane, which is considered to be the most viable and potential energy resource of future world. India with ~4.6 TCM of methane reserves in coal bed can enrich its per capita energy demand by successful exploitation of CBM.

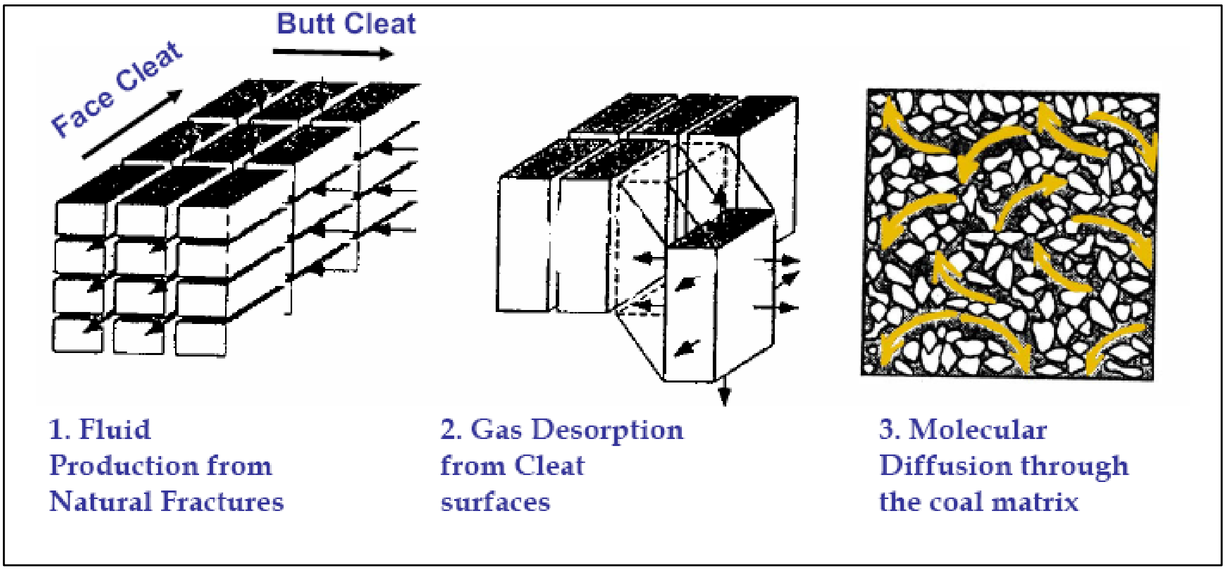

Figure 3: Process of Gas Transport in Coal Bed Methane Reservoirs [8]

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