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Review Article

Underground Coal Gasification (UCG) -A Pilot Study at Certain Area of Jamalganj Coal Basin, Joypurhat District, Bangladesh

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Abstract

Geological Survey of Bangladesh has been entrusted with the responsibilities of investigation and exploration of several kinds of solid mineral resources and discovered four major Gondwana coalfields at southern slope of Rangpur saddle of Bangladesh. Underground Mining is going on only in Barapukuria coal field and the rest of coal fields mining operation at this stage still not possible due to the greater depth. Jamalganj coal basin is one of the largest coal basin of Bangladesh where underground mining method for further mining may be really difficult. Around 4000 million tons of coal deposited in that coalfield which equivalents (due to energy) to about 130 Tcf Gas. It might not be technically feasible or economically viable to mine coal resources of that coalfield till now. Potential for underground coal gasification in the specific area of Jamalganj coalfield of Bangladesh should be needed to study. It has adequate depth (600-800m) and workable overburden as well as their chemical properties of coal (Calorific value-26.84%, Sulfur content- 0.55%, Fixed carbon- 36.72%, Volatile matter- 36.92%, Moisture content and Ash content 3.58%) which might be positive sign for UCG implementation. The high-volatile to medium-volatile bituminous coal is very suitable for UCG exploration in terms of their depth of occurrence, thickness of coal seam, coal reserve and areal extent. The thickest seam-III (over 40 m) can be a primary target for UCG development especially where it combines with seam-II in the eastern part of the coalfield.

Keywords: Coal, energy, Gasification, Gondwana etc.

INTRODUCTION

The Jamalganj Coal Field is located in the vicinity of Jamalganj town and to the west of the north–south broad gauge railway line (Fig-1). Jamalganj Coalfield was discovered in 1962 by the UN sponsored coal exploration program in Bangladesh and Geological Survey of Pakistan/GSP (Present Geological Survey of Bangladesh/GSB). The coal occurs in Gondwana succession within the depth range of 640 to 1158 m. After the discovery, three more consultants including Fried Krupp Roshtaffe, Powell Duffryn Technical Services, and Robertson Research International Ltd. conducted feasibility studies for mining of this coal and recommended that mining Jamalganj is technically feasible. However, no mining project was considered and implemented due to the deeper depth of the coal seams. A total of thirteen core holes were drilled in Jamalganj Coalfield where nine core holes intersected coal seams. About 15 square kilometer is bounded by 3 wells (EDH 7, 8 and 9). And this area was selected for feasible of underground coal mining. This area should be needed to further study for underground coal gasification as a pilot project which might be feasible.

General Information on Jamalganj Area

Jamalganj coal field area is close (8 Km) to district town of Joypurhat and is well connected by railway. The Dhaka-Isnwardih-Dinajpur Railway line of the Bangladesh Railway passes along the eastern fringe of Jamalganj Project area. The area is also connected by all weather National Highways and district road system and the wells are easily approachable. Jamalganj- Joypurhat physiography shows flat alluvial terrain. The area is a relatively highland and termed as Table Land under the physiographic divisions of Bangladesh. The area generally experiences a tropical humid climate. Winter is cold with mercury dipping as low as 9°C; summer is oppressive with temperature often soaring up to 42°C even. During monsoon there is usually heavy rainfall with Annual rainfall varying between 150cm and 170cm.

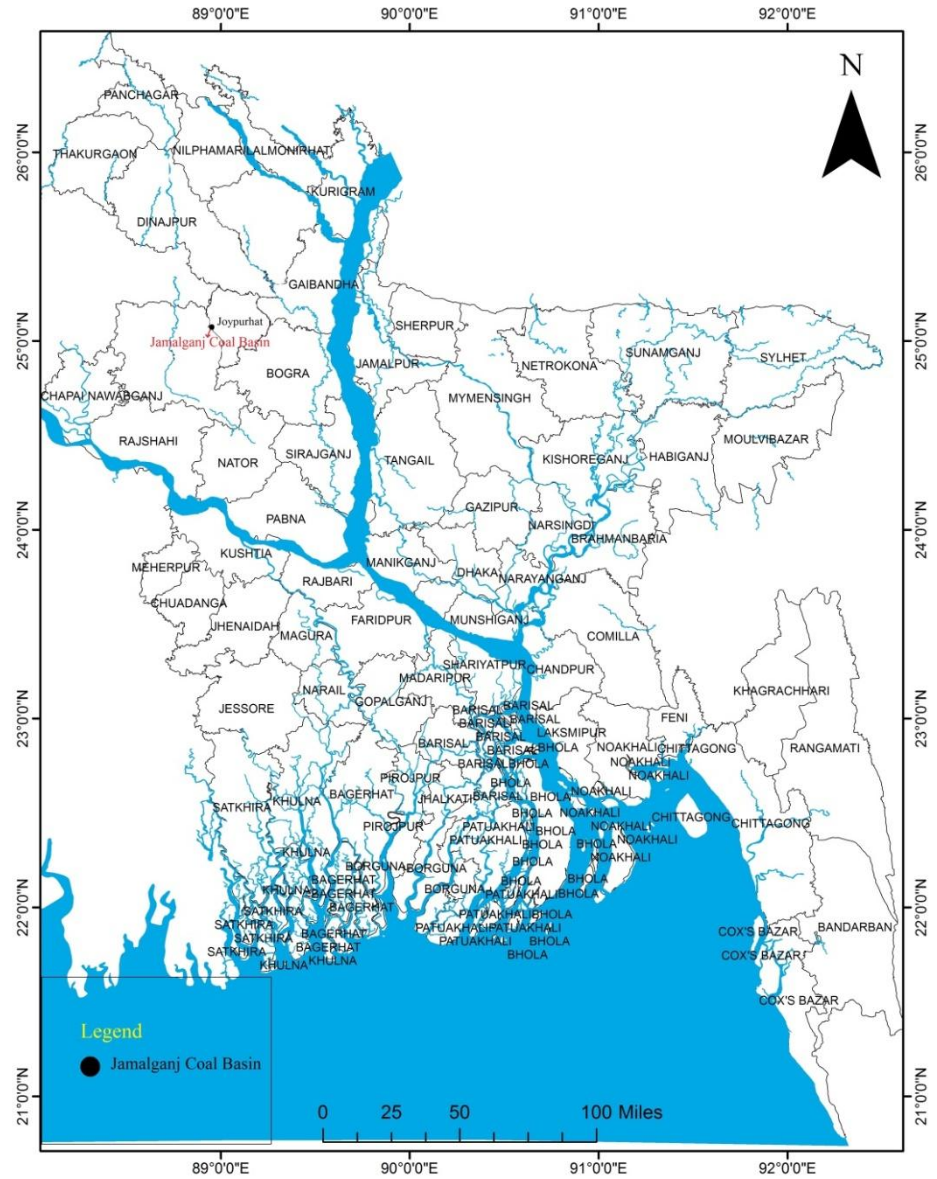

Fig-1: Location map of Jamalganj coal basin, Joypurhat district, Bangladesh

Objective of Jamalganj UCG Study

The largest coal deposit of Bangladesh at Jamalganj has coals occurring at greater depths from commercial coal mining point of view. Government and other agencies in Bangladesh had been trying to find alternate means of utilizing this deeper huge coal resource and might be worked for estimation of UCG resource of this coalfield. For the past several years attempts were made to estimate the UCG resource potential of Jamalganj area. All these estimates were based on UCG parameters like coal thickness and quality, depth, gas saturation, reservoir permeability and sufficient overburden results of adsorption isotherm studies on coals from Barapukuria and coal rank of Jamalganj, which is not industry standard method of UCG resource estimation. The feasibility study for the under ground coal gasification at Jamalganj must be applied the ideal technology which is accepted method of estimation of UCG resource. There was no information available on gas desorption, therefore proper assessment on UCG resources could not be made. Realizing this gap in knowledge detailed and fresh UCG feasibility study should be tested in the area of about 15 sq km in the in the north-western part where the upper coal seams from I to III and at places IV, occurs within a depth range of 600-800m. This area may be considered for underground coal gasification.

Geological Settings

Bangladesh is in the northeastern parts of the Indian Subcontinent between the Indian Shield to the west and the Indo-Myanmar Ranges to the east and shares the geology of the Bengal Basin. In the north, the basin is bounded by the Himalayan Foredeep, the Shillong Plateau and the Assam Basin [1]. The western and southwestern parts of the Bengal Basin consist of an easterly inclined shelf, separated from the Singhbhum Craton of the northeastern part of the Indian

Shield [2]. The Bengal basin demonstrates a broad spectacular combination of three special geological systems and draws individual interests for its relation to the world's largest orogeny system the Great Himalayan Range, the world's largest fluvio-deltaic system; the Bengal Delta (present Bengal Basin) and the world's largest submarine fan system-the Bengal Deep Sea Fan [3]. The evolution of the basin started in the early cretaceous with the rifting of Indian plate away from Antarctica. However, the basin did not become a major depocentre until the northward drifting Indian plate collided with the Eurasian plate resulting in the initial uplift of the Himalayan [4]. The Bengal Basin is one of the largest peripheral collisional foreland basins in South Asia [2, 5] consisting of Permo-carboniferous to Mesozoic and Tertiary deposits covered by the Recent alluvium. The geotectonic of the eastern part of the Indian Plate is dominantly influenced by its collision with the Eurasian Plate [6] to the north and the Burmese Plate to the east, uplifting the Himalaya. Based on its tectonic style and sedimentation history, the Bangladesh part of the Bengal Basin may be divided into three major tectono-stratigraphic units [7]. Stable platform in the northwest, 2) NE-SW trending oriented Hinge Zone and 3) Deep (Geosynclinal) Basin to the east and southeast. The Stable Platform is geologically stable in relative term and has not been affected by fold movement. The NW platform, a gently SE dipping epirogenic platform, is believed to be a part of Gondwanaland, was down warped from Upper Carboniferous onwards creating a number of troughs or graben in the crystalline basement. These grabens are the depositional centers for detritus (coal bearing rock units) derived from nearby elevated shield areas [8]. Gondwana sedimentation continued till late Jurassic under terrestrial and lacustrine environments. On the basis of thickness of sedimentary cover, Stable Platform is divided into: 1) Rangpur Saddle in the north and 2) Bogra Shelf in the south. Rangpur Saddle is believed to be in the form of a dome bounded by N-S trending faults in the east and the west. Rangpur Saddle covers the area of shallow basement representing subsurface continuation of the Indian Shield between the Rajmahal Hills in the west and the Shillong Plateau and Mikir Hills in the east [9]. It slopes both ways towards north and south and forms an oval shaped body (Fig-1). The northern slope of the Rangpur Saddle (Dinajpur Slope) slopes towards northwest, where basement dips sharply towards Sub-Himalayan Foredeep [10].

UCG Resources

Underground coal gasification (UCG) is a potential clean coal technology which converts coal into combustible gas in situ. A significant amount of the world's coal resources are too deep to be mined by traditional methods. However, gasification that occurs underground can convert much of this stranded coal into syngas that can then be used to produce power and other useful products without having to mine it. Typically, the syngas obtained from UCG is used for power generation via the steam turbine route. UCG offers many advantages over the conventional mining and gasification process. It is well proven technology in many countries around the world. UCG was first developed more than a century ago and commercially deployed in the former Soviet Union in the 1950s. Today, the most UCG activity is occurring in Australia, China, and South Africa and China. Recently, China has undertaken 30 more UCG projects in different phases. There are a limited number of projects in Canada and the U.S. In addition, India and New Zealand have begun the initial efforts to explore UCG. Several of these projects involve carbon capture and sequestration. Bangladesh is passing very vulnerable situation in the energy sector. The possible sources and raw material which can be converted into energy are also limited. One of the possible means is coal which could be used for energy production. But it has some affects on environmental pollution caused by its transport, storage, and combustion. To deal with these problems, clean coal technologies have been adopted worldwide such as UCG, which is an auspicious technology as it is a combination of mining, exploitation and gasification. Such kinds of clean and environmental friendly technology UCG might be applied in the certain region (Fig-2) of Jamalganj coal basin area which can be very much conductive for reducing the present energy crisis around the country.

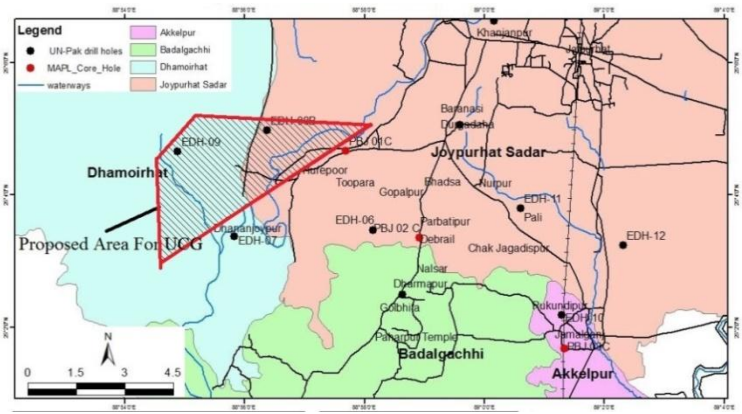

Fig-2: Location map of Proposed Area for UCG at Jamalganj coal basin

Gondwana Rocks and Coal Deposits

The term ″Gondwana” was introduced by Medlicott [11] of Geological Survey of India and includes rocks from Upper Carboniferous to Lower Cretaceous in age. The Gondwana Group of rocks are divided broadly into two (Lower & Upper Gondwana) or three (Lower, Middle & Upper) divisions by different schools. In Bangladesh, subcrops of Gondwana rocks, underlain by Tertiary and Holocene sediments, have been discovered in graben or half graben structures on the Western Foreland Shelf. It has been interpreted that the sedimentation of Gondwana rocks was apparently discontinuous in the half graben structures located on the Western Foreland Shelf. Gondwana coals are intersected at 152m-1150m in small graben structures like Jamalganj, Barapukuria, Dighipara, and other places in Dinajpur and Rangpur districts are High Volatile C to A coal. These coals are earlier considered as equivalent to Lower Gondwana Raniganj Formation of Upper Permian age. In Jamalganj area the non-coal upper 150m-200m of Gondwana was considered as Upper Gondwana (Triassic to Jurassic age). The Gondwana in this area are locally named as Paharpur Formation. Deeper exploration wells near Bogra intersected Gondwana rocks with large number of coal seams. These are high rank coals and for this reason the deeper (>2400m) section of Gondwana had been equated with Lower Permian Barakar Formation. Both the places biostratigraphic age determination was not done and the classification was basically on coal rank. During the present studies drilling of three core holes, continuous coring was done for the whole section of Gondwana Examination of core section fails to reveal any visible discontinuity between coal bearing lower section and non-coal upper parts of Gondwana rocks. However in Indian Gondwana type areas the boundary between Lower and Upper Gondwana (Permo-Triassic boundary) is prominent and widespread—which is completely absent in Jamalganj cores. On the contrary, the upper non-coal part of Gondwana rocks in Jamalganj shows very close similarity with coarse sandstone with minor ferruginous shale/siltstone sequence of Barren Measures (Plate-13) in several Gondwana basins in India such as Bokaro, Jharia, Sohagpur. There is strong lithological similarity between the Non-Coal upper parts of Gondwana of Jamalganj with Barren Measures of some of the Indian Gondwana basins. Also, it may be noted that the coal rank depends on depth of burial (temperature) and not with Formation age. The higher rank Gondwana coals intersected in Bogra wells is due to greater depth of burial and attaining a higher temperature during coalification and is not related to age of the coal. It may be mentioned here that excepting 4- 5 coal fields in India, Barakar coals are low rank bituminous and sub bituminous coals in most of the coal fields. Hence it is may be more appropriate to correlate coals in deep Bogra well and in other shallower basins may belong to same formation (Barakar) only. From these observations, it is suggested that in Jamalganj, the Gondwana strata representing Lower Permian in age and may be divided into a Coal bearing lower part correlating with the Barakar Formation and the non-coal upper part as Barren Measures in conformity with Indian Gondwana basins. The same strata continue towards dip direction (SE ward) up to Bogra.

Quality and Coal Resource Estimation

Subsurface drilling data obtained from the present three core holes and additional 9 wells drilled in early sixties has established continuation of coal seams within the area of present investigation of 64 sq km. There is thickening and thinning of coal seams over the area which is common in any coal forming environment. Attempt has been made to estimate the coal resource of entire area of 64 sq km. The three core holes drilled now are taken as reference wells, and the area is divided into three sectors (as was done for the estimation of CBM resource). Considering the average thickness, density of the coal seams and the sector area, the total coal resource is estimated as 5.45 Bt [14]. These coals are low ash (<20%) bituminous HVB type. Some coal seams intersected in core hole are of higher rank, up to medium volatile and may be used as metallurgical coal, provided it meets other parameters of such coal. Jamalganj coals are thick to super thick, good quality and in fact in 1966 an area of 10.7 sq km was demarcated in the southern part and recommended for underground coal gasification.

UCG FACTORS IDENTIFICATION AND CHARACTERISATION

An analysis of underground coal gasification (UCG) must be related to some specific factors which will be influenced the prospect and operation of that process. Therefore, it is necessary to identify and describe that criterion for further UCG operation. The site characteristics are extremely important to both the operational and environmental performance of UCG and therefore, it is necessary to carefully select the site for any UCG operation. Essentially, the UCG operation occurs with the geological surrounds representing the reaction vessel, so all attributes of the coal seam and adjoining strata can be considered as influencing the process. These can be loosely categorized as coal seam, overburden and hydrology effects and the significance of these is summarized below.

Coal seam properties

There are a number of simple site criteria that are significant influences on the viability of UCG operations. Essentially, both the economic and technical viability of a UCG operation are strongly influenced by the coal seam thickness, depth and ash content. These are the major factors in determining the amount of drilling that is required to access a given volume of carbonaceous material in the coal seam. Water flow into the UCG operation is also a significant factor in determining the product gas quality, so can influence the suitability of a site for either technical or economic reasons, and discontinuities in the coal seam can affect the progress of gasification [12]. Following is a brief discussion of how variations in each of these criteria affect the UCG process.

(a) Thickness

Coal seam thickness is both an economic consideration, as thicker seams allow access to more coal with less drilling and a technical concern, as it affects heat loss during gasification, subsidence and the accompanied aquifer disruption. Soviet research [13] indicated that it was possible to gasify coal in as thin as 1 metre thick seams, however, under the economic conditions prevailing at the time, UCG only become economically viable where the seam exceeded 8 metres in thickness. The definition of a coal seam for UCG operations may actually be comprised of several coal bands where the interburden between the bands is thin enough that the seams will link once collapse is initiated during gasification of the lowest band. No practical maximum thickness of seam has been identified, with seams in excess thickness used at some of the more successful sites. A thickness of coal in combined seams of 20 m or more has been targeted in this study, primarily to improve economics especially when drilling into deeper coals. While the economics and operational performance of UCG are enhanced by use of thick coal seams, there are detrimental environmental impacts that should be considered. The collapse of overburden into the cavity created in a thick coal seam will have greater likelihood of causing subsidence at the surface, although this can be mitigated by the use of deeper coal seams, and is more likely to disrupt overlying aquifer systems, potentially leading to contamination issues. The overburden properties and site hydrological characteristics will have a substantial influence on these impacts. Targeting the upper coal seams (I –IV) the cumulative thickness would be around 25m with individual seams 1.5m to 10m and suits for coal gasification (Fig 3 and 4).

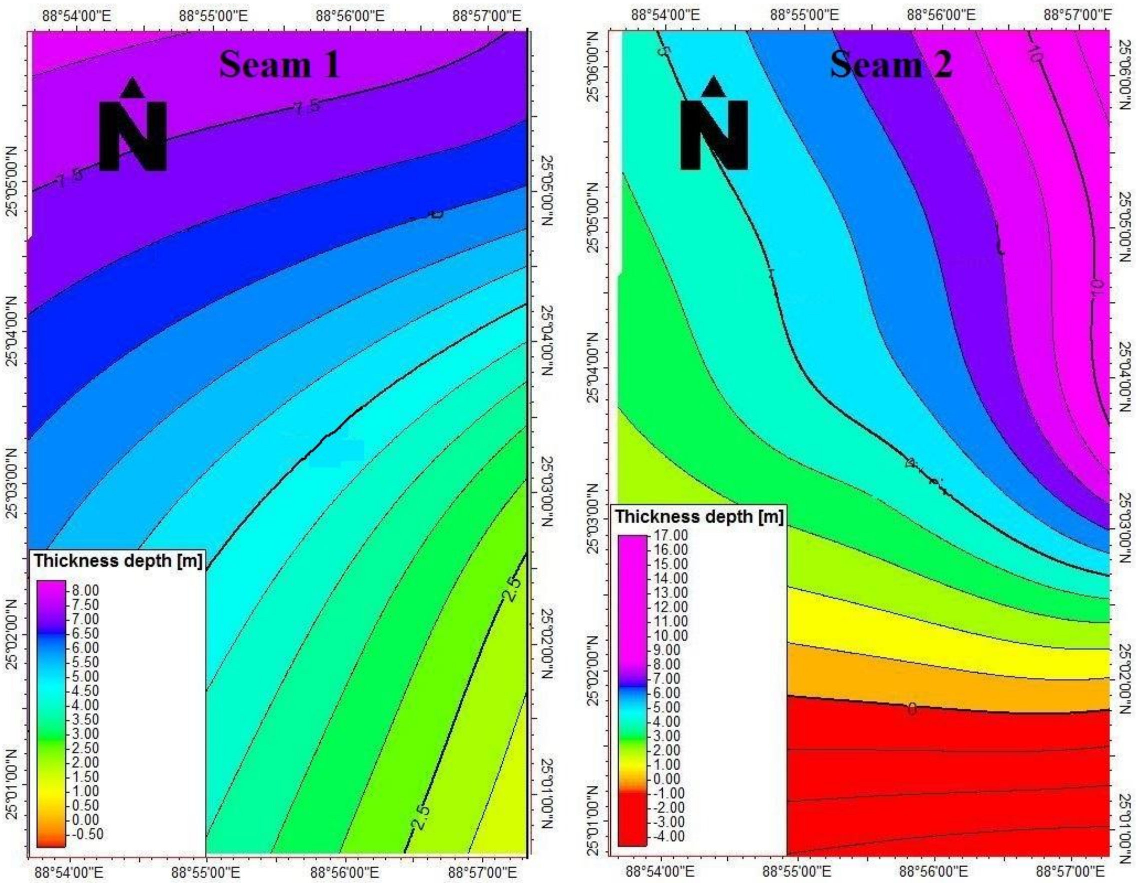

Fig-3: Isopach of seam 1 and 2, Jamalganj coal basin, Joypurhat district, Bangladesh (modified from Adhikari *et al.*, 2016 [14])

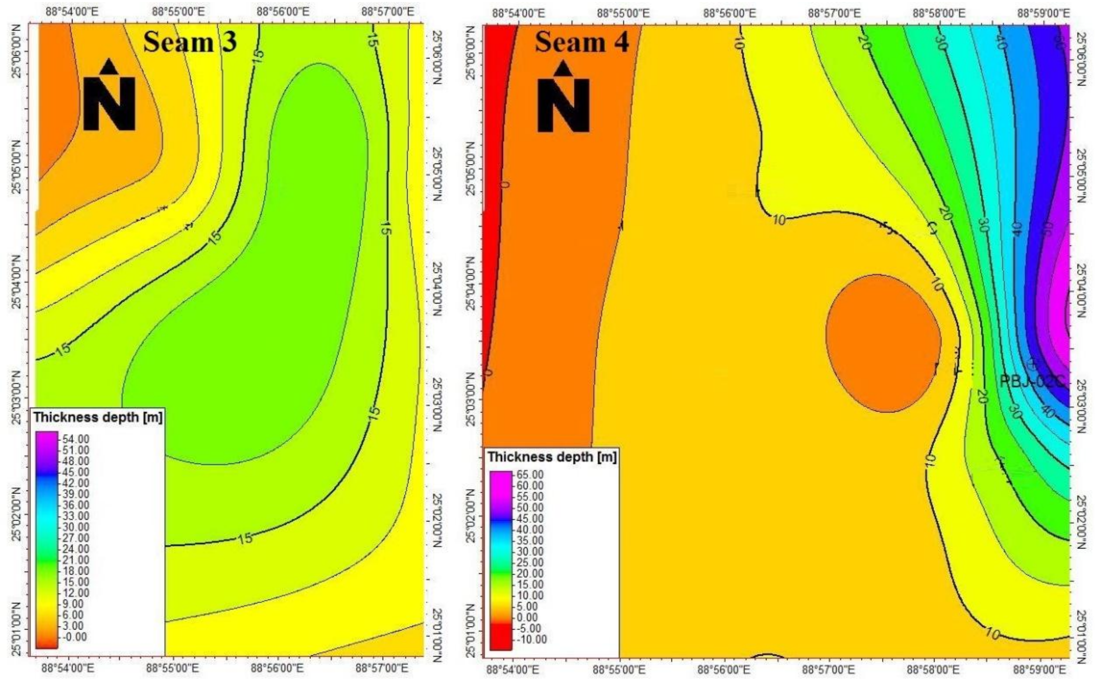

Fig-4: Isopach of seam 3 and 4, Jamalganj coal basin, Joypurhat district, Bangladesh (modified from Adhikari *et al.*, 2016 [14])

Depth

The coal seam depth has a number of different impacts on UCG operation and environmental impact. From an operational viewpoint, the maximum operating pressure of a UCG site is determined by the hydrostatic head at the coal seam and this is strongly influence by the seam depth. For deep coal there is less likely to be a shortage of groundwater around the seam and the hydrostatic head is likely to have less significant change during operations, leading to increased operation stability and less risk of gas loss. The cost of drilling increases with depth and there is a practical limit to the capabilities of current drilling technology, with depths greater than 600m being problematic and expensive. In terms of environmental risk, subsidence at the surface typically decreases for removal of coal at greater depths and there is less likelihood of interfering with other users of the groundwater, either by contamination or depletion of water near the coal seam. Selection of the depth of coal seam that should be targeted during site identification is complicated by the competing influences of economics, subsidence and groundwater impact. Also, there are different UCG reactor designs that can be used to minimize environmental impact for different sites, for example narrow cavities can reduce subsidence impacts for shallow UCG operations. The decision was made to target a site at 350 to 400 m depth for the primary reason that the operating pressure at this depth is sufficient to operate a combined cycle gas turbine plant without product gas compression being required. At these pressures there would be minimal modification required to use plant items developed for surface coal gasification processes with the UCG process. The depth proposed would be a relatively deep UCG operation as most operations of significant scale have been shallower than 200m with only relatively small trials being performed at depths greater than 300m. Technically, current drilling technology is suitable for these depths, as UCG trials at depths of greater than 600m have demonstrated and coal of this depth is often targeted in Australia using similar drilling techniques for coal bed methane extraction. There are a number of advantages associated with the use of deeper coal seams, including smaller relative change in operating pressure with time – There is less change in hydrostatic head with time due to the increased area for replenishment of the water table above the UCG site and this can improve the operating performance of both the UCG reactor and surface plant. Reduced environmental impact – Deeper groundwater is less likely to be extracted for surface use, so if contamination occurs it will have less significance. Maintaining a higher water table will also reduce the potential for damage to surface vegetation and gas leakage. · Improved product gas quality – An increase in the operating pressure results in more intense gasification conditions with higher temperatures, and this leads to a higher quality product gas with less tar components and higher calorific value after cleaning. This advantage increases with the use of oxygen rather than air and results in lower carbon dioxide emissions from the process, an important environmental factor due to the Greenhouse gas effect. Higher process efficiency – The higher product gas pressure makes the gas suitable for use in the process without further compression. The feed gas must be compressed more for the deeper operation, but this is a smaller volume flow than the product gas, is at room temperature and the energy that can be recovered from the product stream is greater than the energy expended in feed compression.· Smaller wells – Due to the higher pressure there is a smaller volume flow of feed and product gas for the same capacity of UCG site and smaller wells can be used, with a cost reduction that can partially or fully compensate for the increased costs with greater depth and pressure. This can also justify the use of oxygen, which has about 20% the volume of air for the same plant capacity, but note that higher-grade materials are required in the wells for oxygen feed. As stated earlier, the upper coal seams (I –IV) would occur at 600-800m depth in the proposed area of Jamalganj coal basin.

Ash

Coal ash content has been shown in Soviet research [13] to be of only minor significance in the performance of UCG operations, with no discernable decline in performance for ash content up to 40%. In theory, increasing ash content should reduce performance because of the energy consumption involved in heating the ash up to the operating temperature of the gasifier. However, the ash will also cool again as the gasification front moves through the coal seam and some of this energy will be recovered in the product gas. The lack of sensitivity to ash content has resulted in UCG being suggested as an utilization technology for high ash coal seams, which are often difficult to mine economically using conventional techniques. The coal seams of Jamalganj coal basin contain about 20% ash which is also positive factors for UCG prospect of study area.

Discontinuities

One of the key requirements of UCG is that the coal seam be essentially free of significant discontinuities, such as faults. Minor disruptions to the seam can be acceptable, but major breaks in the coal will lead to difficulties in getting gas flow through the coal and can lead to high gas leakage rates from the UCG cavity. If the discontinuities are identified in the site characterization and are sparsely distributed, it may be possible to design the UCG layout to minimize the impact on operations. There are potential environmental issues from the discontinuities, as there is increased risk of leakage of contaminants from the site.

Rank

Coal rank has been the subject of some examination during previous UCG research activities. Soviet researchers experimented on all ranks of coal and found little sensitivity to rank [13]. The USA researchers concluded that high rank coal was difficult to ignite and that swelling bituminous coals required careful design to limit the risk of blockages occurring [15], however this appears to have been theoretical conclusions rather than Soviet conclusions based on practical experience. Another potential issue is that low rank coals tend to have excessive moisture content that will impact on UCG performance. In the region of interest for this study the coal rank is typically high volatile bituminous with minimal swell, which classes it as suitable for UCG.

Overburden properties

The strata overlying the coal seam have two effects on gasification. Firstly, they can provide water that flows into the gasification void and, secondly, they will collapse into the void when thermally damaged and insufficiently supported. Soviet research [13] suggest that the ideal roof strata is of low permeability, preferably lower than the permeability of the coal itself, so that water ingress from the roof will be minimal and gas escape unlikely. In addition, it is preferred that the roof material swell when heated and break into small pieces to fall at a stable and slow rate. Some materials, such as mudstone or siltstone, may fuse on heating to provide stronger and less permeable overlying strata that would be beneficial to the process. There can be distinctly different forms of undesirable behavior resulting from roof material that is unsuitable. Material that is not significantly affected by heat and a lack of support can result in excessively large cavities, into which injected gases diffuse to the extent that they have negligible reaction with the coal or char. In contrast, fragile material that collapses easily can result in blockage of injection and production pipes or even fill the gasifier void itself. Another possibility is that a zone of high permeability will occur in the overlying strata and gas flow will bypass the coal containing regions, leading to un-reacted oxygen entering the production pipe. Excessive disruption of the overlying strata can also lead to disruption of aquifer systems, resulting in mixing of different quality water and possible contamination of clean groundwater bodies. It is also desirable that the overburden behavior be predictable during UCG operations. The design of a UCG site relies upon assumptions regarding the rate of collapse of the overburden. Excessive variability in collapse characteristics during operation could lead to large fluctuations in gas quality and production rate. For this reason it is best to avoid sites with overburden that is heavily faulted or consists of unconsolidated materials of varied composition. The study area has huge overburden which are Dupi Tila (Sandstone+Shale), Jamalganj (Sandstone+Shale), Bogra (Sandstone+Shale), Kopili (Shale), Limestone, Tura (Sandstone) and coal barren upper Gondwana formation (Fig-5). It is another good sign for UCG prospect.

Hydrology

Water is essential to the operation of a high efficiency UCG process, as it provides a seal around the gasification cavity that limits escape of gas and the correct quantity participating in the reactions results in higher quality product gas. The operating pressure of a UCG reactor should be kept lower than the hydrostatic head at the seam, so water will flow into the cavity continuously and sufficient groundwater should be available to maintain this flow without depleting the site water resources excessively. The D:\UCG availability of water at a site is influenced by the depth of the subject coal seam and the permeability of the materials around the UCG reactor, so these are key issues in the selection of a site. Low permeability overburden is preferable to reduce the risk of flooding of the cavity during operations. The presence of clean waters close to the coal seam raises the issue of potential groundwater contamination. This can occur due to operational problems forcing pyrolysis products from the affected coal into aquifers, but is more likely to be a serious issue if aquifers are disrupted due to subsidence in the vicinity of gasifier void. This can lead to clean waters mixing with those directly in contact with heat affected coal or possibly flowing through the coal. At sites where water is extracted for domestic or agricultural use from the vicinity of the coal seam, it is likely that the site would be deemed unsuitable for UCG by local authorities. Therefore, sites with poor quality groundwater are preferred for UCG operations, regardless of other controls that may be used to limit the risk of groundwater contamination. Generally, local people of Jamalganj area extracted ground water for drinking purpose from Dupi Tila formation which is in the upper part of that basin. But another aquifer which is immediately upper part of coal seam in the Tura formation (Fig-5). This aquifer cannot be used as drinking purpose which can be used for UCG operation.

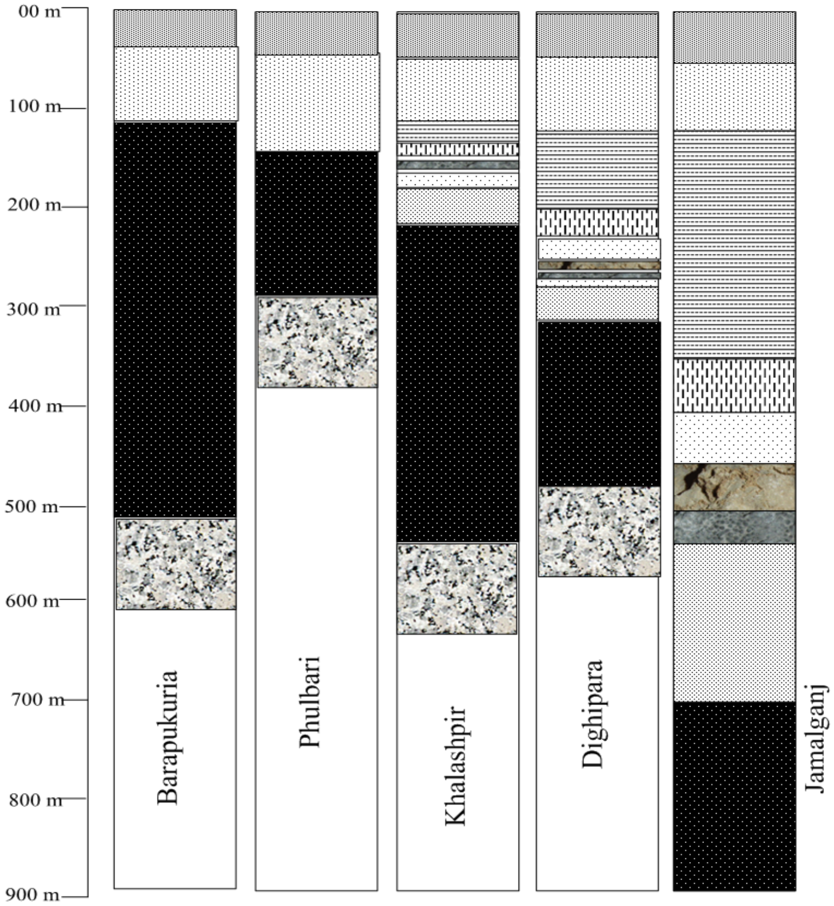

Fig-5: Correlation of five coal fields Bangladesh (overburden, Hydrology)

Underground Temperature

Geophysical temperature log data shows that at 600- 800m depth range the temperature would vary from 38^o to 45^o and should not be great problem in underground coal gasification in this western part of Jamalganj coalfield.

Coal density

Apart from density logs available for each core hole, bulk density was measured on whole coal core samples in the lab. The measurement is done by submerging the core in distilled water in a graduated cylinder while weighing the core and the core with water. This lab tested density was compared with density log values. For each coal seam of interest, average density was calculated based on 1.80g/cc log density cut-off, using LAS digital data files in combination with lab tested density. Appendix-VII contains Geophysical Logs showing coal seam density variation and depths.

- Coal seam of thickness 10 metres or more (good economics for coal recovery)
- No disruptions to seam continuity (simplifies layout and operation)
- Minimal dip in seam (dip has process pressure control ramifications)
- Depth of between 300 and 400m (good reaction pressure and drilling costs)
- High hydrostatic head (ensures good water seal around gasification cavity)

- Low permeability of overburden (minimal water flow into cavity)
- Ash content of the coal less than 40% (ad basis) (gas quality issue)
- Overburden unlikely to suffer major collapse under thermal and mechanical stress
- No good quality aquifers close to coal seam (contamination issue)
- Surface conditions suitable for low impact activities and some subsidence

Operational risks of UCG

A number of operational problems have resulted in poor performance or complete failure of UCG operations. This is not surprising considering the large number of tests performed, the large number of different site operators and the experimental nature of the techniques used. The most common problems are discussed below, with indications of the probability of occurrence and potential methods of avoiding these types of problems.

(a) Drilling problems

There are two different types of drilling problems that are likely to affect the establishment and operation of an UCG site. The first of these is inaccuracy in directing the drilling which can lead to any number of difficulties in linking and igniting the gasifier. Another type of drilling problem relates to the material through which the drilling is occurring. Obviously, very hard rock will add to the cost of drilling due to increased wear on equipment; however a large component of the drilling cost is in the usage of drilling mud. Drilling through overly porous material, such as old mine workings or possibly even disturbed soil, will lead to increased mud usage and may require more expensive techniques. In the extreme, it may be necessary to cement the material so that it can be drilled, which would add substantially to the cost and time taken. Similar problems can occur with soft coal seams, where the drilled hole can collapse on the drill. This can lead to loss of the drilling equipment.

(b) Poor flow from injection to product holes

This is a very common problem in early tests, it is caused by having low permeability material between the injection and production holes. A number of techniques have been tested in the USSR to increase this permeability. These include hydro-fracturing or explosive fracturing of the coal and passing electrical current between the holes, however the most reliable method, that has been almost universally adopted, is reverse combustion linking. This entails igniting the coal at one hole and supplying oxygen (or air) at the other, so that a path is burnt through the coal. Obviously, if no flow can be maintained this will not be successful and the holes will have to drill closer together. The required spacing of the holes is therefore related to coal permeability.

(c) Inability to ignite the coal seam

Ignition of the coal seam has been achieved quite readily in most underground gasification trials, typically through the addition of a highly flammable substance and electrical ignition. However, in other trials it has proved extremely difficult, although it has been rare for ignition problems to result in abandonment of a test. Ignition is usually achieved through the addition of large quantities of liquid hydrocarbon fuels (eg. Diesel) or occasionally through methane injection prior to subsequent ignition attempts. As a first step, silane is commonly used in shallow to moderate depth seams as it spontaneously combusts on contact with air, however this process is inhibited at high pressures and can therefore cause an ignition failures. A common cause of ignition failures is high water ingress rates, which is particularly problematical with deep coal seams such as used during the Thulin trials. It appears that ignition is relatively simple where the coal seam contains significant quantities of methane.

(d) Casing failure

The piping used for the feed and product holes of the gasification site is subjected to various stresses, mainly caused by ground movement and high temperatures. In early Soviet tests the pipe failure rate was in excess of 20% of the pipes used, however this was reduced to less than 10% with experience and the use of improved grouting cements. The rate of failure was probably exasperated by reuse of the pipework in the Soviet operations and the shallow operating depths leading to heavy subsidence. Operational changes used to reduce the failure rate include angling the pipes to avoid the subsidence zone over the gasifier void and always maintaining some airflow into the gasifier to cool the pipes. Another cause of casing failure that is avoidable is high pressure, which is the result of inadequate pressure relief when a pipe becomes blocked. .

(e) Roof collapse

Roof collapse is a common occurrence in underground gasification operations and is a result of the growth of the gasifier void and thermal cracking of the overburden. Collapse can only be avoided by the retention of support pillars adjacent to the gasifier void, however it is more likely to be an accepted part of the site design with pillars being retained only to prevent excessive subsidence at ground level. In some cases roof collapse has caused serious problems in the gasifier, usually when it has resulted in blockage of the injection pipe. In the El Tremedal/Alcorisa test the roof collapse led to injection pipe damage and also a rapid increase in the water ingress rate due to the overburden being essentially wet sand. In order to minimize the impact of roof collapse on UCG activities a site design that accounts for the breakage characteristics of the overlying strata when exposed to thermal stress should be used. This will determine the maximum span that should occur between pillars and, possible, an acceptable rate of growth for the gasifier. A problem that can occur with excessive roof collapse is gas bypassing, caused when the injected gas passes through a void in rock, rather than coal, and therefore reaches the product hole without reacting. This has happened in a number of trials and can lead to a section of coal not being gasified. It is important to direct injected gases low in the coal seam to minimize the risk of this occurring.

(f) Flooding

The flooding of a gasification site will typically be related to some other operational problem. Coal seams are typically within aquifers, excepting if they are exceptional shallow seams, and therefore the gasifier void will resemble a bubble in the wet solid. The operating pressure of the gasifier will be sufficient to prevent excessive ingress of water but should not be overly high so as to reduce gas losses. In typical operation it is expected that water will flow into the lower part of the void but be held out at the higher parts, due to slightly higher hydrostatic pressure at the greater depth. If the operating pressure drops due to faults in the plant or a higher permeability section of rock is exposed with collapse of roofing material, water will flow in more rapidly and may extinguish the burning coal. Once the coal is extinguished it may prove difficult to re-ignite, as the water must be forced from the void and an ignitable section of coal exposed to a flame at sufficiently high temperatures. Flooding is therefore avoided by careful monitoring of the gasifier to control water ingress and possibly relocation of the injection point.

CONCLUSION AND RECOMMENDATION

Bangladesh is one of the poor and developing countries which suffer from a serious shortage of internal sources of electricity production. About 90% of the country has electricity coverage where most of the sources of electricity is coming from abroad as imported. Sometimes frequent power cuts also cause several problems. In order to improve the internal sources electricity production, Underground Coal Gasification (UCG) can be installed at Jamalganj coal basin (south-western part). The maximum positive factors (thickness of coal seam, huge overburden, hydrology and temperature system, quality of coal etc.) of that certain area of Jamalganj coal basin might be preferable for underground coal gasification (UCG) which can be very much feasible for reducing the present energy crisis around the country.

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