ASME PAPER NEW ORLEANS

EXTRACTION AND UTILIZATION OF METHANE FROM COALBEDS

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Methane is inherent with coal mining and for years has been a product requiring disposal so that mining operations can continue. Since it has a Btu rating and chemical composition comparable to natural gas, and is approximately three times as abundant, it is prudent to make use of this product as an auxiliary energy source particularly since existing conversion equipment is available to use it.

Westinghouse is actively involved in a project in Pennsylvania to demonstrate technical and economic feasibility for the extraction and utilization of methane at a Westinghouse plant site.

A well was drilled and completed 750 feet deep through 12 coal seams totaling about 27 feet of coal. This well delivers 99.2% methane to the plant and has produced in excess of 50 mcf/day. A system to effectively drain the site will be constructed and put into operation later this year.

EXTRACTION AND UTILIZATION OF METHANE FROM COALBEDS

Methane is associated with most coal mining operations. The word methane does not mean much to the average person on the street even though the natural gas used in his or her home is 95% methane. But to coal mine owners, operators and miners, the word has a very significant meaning and the usual reaction to its discovery is to dispose of it quickly. Disposal of methane has been going on in the United States for years through predrainage operations in advance of mining, mine vent holes and mine ventilation. Thus, we in this country, as an everyday operation, have been exhausting to the atmosphere an energy source exhibiting up to 1000 Btu per cubic foot while striving to extract coal from underground mines for use as an energy source. There is no doubt that methane above certain concentration levels represents a hazard to the miners, but maintaining a level low enough to provide a safe working environment does not mean that a clean burning, high quality fuel should be wasted. This is particularly true when the energy situation existing today is taken into consideration. Recognizing the potential that methane possesses as an energy source, and the vast amount of coal within the United States, Westinghouse Electric Corporation has become actively engaged in the extraction and utilization of this resource.

The project to be discussed is occurring at an 850 acre plant site owned and operated by Westinghouse in Westmoreland County, Pennsylvania. In May 1978, Westinghouse entered into a contract with the United States Department of Energy to demonstrate technical and economic feasibility for the extraction and utilization of coalbed methane.

The project was divided into three phases to be performed in sequence. The first phase was intended to establish the credibility of the site as a methane reservoir. The second phase was to further explore the site for methane, obtain operating history on the well developed in the first phase, and design a system to effectively drain the site and tie into an existing plant pipeline. In the third phase, the system previously designed will be constructed and put into operation. The first two phases have been completed and the third phase will start later this year.

In the first phase two wells were drilled. One was designated as a production well and the other as an observation well. The two wells are about 400 feet apart. The observation well was cored to a depth of 640 feet using an NX wireline retrievable coring rig. About 27 feet of coal were uncovered in 12 seams. The coals penetrated are the Allegheny group of coals, starting with the Upper Freeport seam and ending with the Lower Sharon seam. Two inch diameter core samples were taken of the coal seams for analysis of the gas content. These core samples were placed in individual canisters and at scheduled time intervals samples of desorbed gas were withdrawn for analysis. Results of the core sample data are presented in Table I.

Core samples were placed in individual cans for analysis and immediately sealed to retain the gas escaping from the coal. Because of the wireline retrievable core barrel, shallow depth, and good core handling procedures, the time from coring the coal to getting the samples into the canisters was held to an absolute minimum, sometimes as short a time as five minutes. The results obtained from these samples are therefore considered to be very representative of the actual gas content in the immediate vicinity of the observation well.

The gas content of the coal appears to be low. The weighted average gas content is 1.16 cc/gm over the 27 feet of coal. This computes to be 1850 Mcf/acre. While this is thought to be low, it will sustain flow rates of 25 Mcf/day for ten years with a low recovery factor for wells drilled on 160 acre spacing.

TABLE I

CORE DATA SUMMARY (FIRST SITE)

Coal Seam	Seam Depth Feet	Seam Thickness Inches	Gas Content cc/g
Upper Freeport	187 - 189.3	28	.376
Lower Freeport	237 - 243	74	(.458) (.648) (.821)*
Upper Kittanning	324 - 326	25	.807
Lower Kittanning	384 - 389	62	(1.669) (1.628)**
Clarion	432 - 435.5	46	.723
Brookville	458 - 459.5	18	.878
Upper Mercer	477.5 - 479	15	1.978
Middle Mercer	517 - 518	14	.966
Lower Mercer	552 - 554	24	1.482
Quakertown	589	5	1.441
Upper Sharon	618	4	1.846
Lower Sharon	628.5	8	3.245

*Three samples taken because of seam thickness.
**Two samples taken because of seam thickness.

The production well was drilled to a depth of 767 feet at a diameter of 7-7/8 inches using an air rotary rig. This was followed by open hole logging, installation of casing, cementing of the cased hole, and logging of the cased hole. The casing was 5-1/2 inches O.D., 14 lb/ft, K-55 material.

The next operations occurring in the production well were perforating and fracturing. The twelve coal seams were divided so that the well was fractured in four zones with five stages in each zone. The lowest zone was not able to be fracked possibly because the coal seams were so thin. The stimulation treatment consumed 76,000 pounds of 20 - 40 mesh sand and about 270,000 gallons of water. Table II shows a summary of the stimulation process.

all installed in March 1979, and methane gas started to flow into the plant.

The production well has a submersible pump installed at an elevation of 550 feet. Originally, this pump was located at 700 feet, but due to becoming clogged with sand, it was removed and replaced at the higher elevation. Switches are located at the 430 and 525 foot depths for the purposes of starting or stopping the pump depending on the water level. When the water level builds up to 430 feet, the pump is turned on and remains in operation until the 525 foot level is reached. While the pump is operating, water flow rates are in the vicinity of 10 gpm. Since the pump was relocated at the higher elevation, there has been no significant problem with the operation of the well.

TABLE II

STIMULATION SUMMARY

Zone/Stages	Perforations Depth	Number of Holes	Sand LB	Volume Pumped BBL	Rate BPM	Pressure PSIG
1/1	657-58	2	0	145	8	3800
	652-53	2				
	645-47	3				
	614-16	5				
2/5	570-72	4	26,000	2105	26	2100
	530-32	4				
	490-92	4				
3/5	449-52	6	26,000	2145	30	2700 - 1000
	385-88	6				
4/5	333-35	4	24,000	2080	32	1200
	256-58	4				
	193-95	4				
TOTAL		48	76,000	6475		

A gas sample was taken for analysis to determine its quality. This analysis is shown in Table III. The analysis results show the gas to be of very high quality.

While the coring, drilling and analysis of cores was proceeding, equipment was ordered to complete the hookup of the well to the existing plant pipeline system. This equipment included a gas processing station, pipeline, wellhead equipment, submersible pump, electric power, fencing, etc. These hardware items were

The methane produced by the well is delivered via a gas processing station and an underground pipeline to a location inside the plant fence where it is comingled with the natural gas delivered by a local utility. The gas processing station separates out any moisture, filters out particulate matter, monitors the flow and regulates the outlet pressure. After comingling, the methane/natural gas fuel combination is distributed throughout the plant to the various boilers where it is burned. There has been no noticeable

change in the performance of the conversion equipment while using the comingled gas as a fuel.

TABLE III

GAS ANALYSIS

Constituent	Mol %
Methane, CH_4	99.22
Oxygen, O_2	0.00
Carbon Dioxide, CO_2	0.51
Hydrogen, H_2	0.04
Nitrogen, N_2	0.22
Argon, Ar_2	0.01
Water, H_2O	0.00
TOTAL	100.00

In the period before the well was tied into the plant system, it was in the free flowing condition. Flow rates varied considerably up to values in excess of 80 Mcf/day. However, once the well became an integral part of the plant system, the well flow rate became dependent upon the needs of the plant. Flow rates have varied up to 85 Mcf/day while in this configuration. There have been several days when the well has supplied 100% of the gas consumed by the plant.

An economic analysis was performed with the following assumptions:

- 60% recovery of the resource
- 6 wells required to develop the site
- System lifetime of 12 years
- A long term daily flow of 35,900 SCF/well with an assumed quality of 1000 Btu/SCF
- Costs escalating at the rate of 8%/year

With the above assumptions the economic analysis indicates that over a twelve year period the system will:

- Pay for itself
- Earn 15% on the initial investment
- Yield a cash income whose present worth exceeds $300,000

This concluded the first phase of the project and based on the results obtained the decision was made to proceed into the second phase. As indicated earlier, an objective of the second phase is a further exploration and definition of the site as a methane reservoir. To accomplish this three additional locations were selected on the site for coring. At two of these locations drill stem tests were performed.

Reasons for the relatively low gas content encountered in the first phase were:

- The relatively close location of the well to a mined out area.
- The relatively shallow overburden.

Consequently, the first additional location was selected at about the same elevation as the first site, but at a greater distance from the mined out area. This well was cored to a depth of 709 feet through nine coal seams having a total thickness of about 20 feet. The same techniques for core recovery and analysis were used as in the first phase. The results showed that the gas content increased to 60 cubic feet per ton which is 62% greater than that exhibited at the production well. Table IV shows the results of core analysis for this site.

At the second location in this phase, the distance from the mined out area is increased and the overburden is about 240 feet greater. This hole was cored to a depth of 1150 feet and subsequently reamed for drill stem testing to a depth of 1075 feet. Again, following the same techniques for core recovery and analysis, the results obtained indicated 75 cubic feet per ton of coal which is an increase of 102% over the production well. Nine coal seams were uncovered having a total thickness of 17 feet. These results are shown in Table V.

TABLE IV

COAL SEAM	SEAM DEPTH FEET	SEAM THICKNESS FEET	GAS CONTENT cc/gm
LOCAL	190	0 3	0 617
UPPER FREEPORT	210	4 4	2 157
LOWER FREEPORT	303	2 8	0 696
MIDDLE KITTANNING	385	1 7	2 496
CLARION	433	3 2	2 649
MIDDLE MERCER	484	3 7	1 759
LOWER MERCER	524	1 0	1 072
LOCAL	610	1 7	1 611
LOCAL	690	0 6	1 336

TOTAL SEAM THICKNESS 19 4 FT
WEIGHTED AVERAGE 1 875 cc/gm 160 FT³ TON

TABLE V

COAL SEAM	SEAM DEPTH FEET	SEAM THICKNESS FEET	GAS CONTENT cc/gm
LOCAL	527 7	0 8	1 095
UPPER FREEPORT	575 8	2 5	1 345
LOWER FREEPORT	641 5	2 5	1 678
MIDDLE KITTANNING	719 1	1 5	2 186
CLARION	787 0	2 8	3 460
MIDDLE MERCER	831 2	3 4	2 762
LOCAL	976 7	2 6	2 061
LOCAL	1009 5	0 5	1 475
LOCAL	1043 5	0 6	1 970

TOTAL SEAM THICKNESS 17 2 FT
WEIGHTED AVERAGE 2 343 cc/gm 75 FT³/TON

The third location in this phase was at an elevation about 240 feet greater than the production well, but at the same distance from the mined out area. This location was cored to a depth of 970 feet and subsequently reamed to the same depth for drill stem testing. Results of core analysis from this location show 64 cubic feet per ton of coal which is 73% greater than that at the productive well. Results from core analysis of this site are shown in Table VI.

Combining the results obtained from the core samples, the performance of the production well, and correlating the logs from the various wells, the methane content of the site was calculated to be in excess of 2600 Mcf/acre. Thus the credibility of the site as a methane reservoir was established, and a system design for six wells was proposed to effectively drain the site. Construction of this system is expected to be underway in the spring of 1980.

In the total system, each of the additional wells will be equipped similarly to the production well. A

TABLE VI

CORE DATA SUMMARY (FOURTH SITE)

COAL SEAM	SEAM DEPTH FEET	SEAM THICKNESS FEET	GAS CONTENT cc/gm
UPPER FREEPORT	437 2	2 8	1 38
		1 9	1 13
LOCAL	484 5	5 5	1 38
MIDDLE KITTANNING	568 2	1 8	2 86
LOCAL	635 9	3 6	3 13
		1 0	2 36
MIDDLE MERCER	687 8	1 2	3 33
		2 5	1 34
LOWER MERCER	728 3	0 9	1 83
QUAKERTOWN	760 3	0 4	2 46
LOCAL	783 0	0 8	1 42
SHARON	786 6	1 4	2 48
LOCAL	810 0	1 3	2 58

TOTAL SEAM THICKNESS 25 1 FT
WEIGHTED AVERAGE 2 0 cc/gm (64 FT^3/TON)

network of underground tubing will carry gas and water from each well and supply electric power to each well for its pump. In addition, one well will supply methane directly to a small fuel cell unit which will be demonstrated in this phase. The anticipated length of the third phase of the project is about two years. In that time span, the last 9 to 12 months will be used to operate and collect data from the entire system.

In summary, a sequential three phase project was initiated to demonstrate the technical and economic feasibility of extracting and utilizing methane from coalbeds. The first two phases have been completed and the objectives of these phases satisfied. The third phase will commence later this year and continue for two years which will include up to one year of operation of the entire system. Total site development is expected to achieve program objectives and confirm the technical and economic feasibility of extracting and utilizing methane from coalbeds.