Conf-920951--30

DOE/MC/27339-93/C0112

Current Status of Design and Construction of ENCOAL Mild Gasification Plant

Authors:
Frederick, J.P.
Siddoway, M.A.
Coolidge, D.W.

DOE/MC/27339--93/C0112

DE93 002610

Contractor:
ENCOAL Corporation
P.O. Box 3038
Gillette, WY 82717

Contract Number:
DE-FC21-90MC27339

Conference Title:
Twelfth Annual Gasification and Gas Stream Cleanup Contractors Review Meeting

Conference Location:
Morgantown, West Virginia

Conference Dates:
September 15-17, 1992

Conference Sponsor:
U.S. Department of Energy, Morgantown Energy Technology Center

Current Status of Design and Construction of ENCOAL Mild Gasification Plant

CONTRACT INFORMATION

Contract Number	DE-FC21-90MC27339
Contractor	ENCOAL Corporation P.O. Box 3038 Gillette, WY 82717 (307) 686-5492
Contractor Project Manager	James P. Frederick
Principle Investigators	Dr. Mark A. Siddoway Dennis W. Coolidge
METC Project Manager	Douglas M. Jewell
Period Of Performance	07/17/91 to 09/17/92

Schedule and Milestones

	FY 1991			FY 1992											
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Construction	----	----	----	----	----	----	----	----							
Commissioning						----	----	----	----						
Start-Up								----	----	----	----	----			
Plant Testing												----	----	----	

OBJECTIVES

ENCOAL's overall objective for their Mild Coal Gasification Project is to further the development of full sized commercial plants using the Liquids From Coal (LFC) Technology. In support of this overall objective, the following general objectives were established for the project:

1. Provide products for test burns
2. Develop data for the design of future commercial plants
3. Demonstrate plant and process performance
4. Provide capital and operating cost data
5. Support future LFC Technology licensing efforts

Specifically, the objectives for the period ending September 30, 1992 which includes completion of Phase II and the start of Phase III are as follows:

1. Complete all construction activities and have DOE review
2. Effectively train operations and support staff
3. Prepare Commissioning, Start-up, Shut-down and Test Plans
4. Complete all HAZ-OP and environmental permitting requirements
5. Commission and test plant piping and equipment systems
6. Start-up and operate plant for at least 24 hours in an integrated mode and make specification products
7. Submit public design report
8. Prepare Evaluation Report and receive approval on ENCOAL's Continuation Application
9. Perform plant modifications as required to improve operations
10. Deliver initial products to test burn customers

All of the specific objectives for this period have been met except for the delivery of products. This is because the plant has not yet had continuous runs for long enough to make the required volumes of products. A significant number of plant modifications have been made to improve plant operability and reliability and move closer to the last objective.

BACKGROUND INFORMATION

General Description

ENCOAL Corporation is a wholly owned subsidiary of Shell Mining Company (SMC) formed for the purpose of entering into a Cooperative Agreement with the DOE and carrying out the Mild Coal Gasification Project. ENCOAL has been granted a license for the use of the LFC Technology from the technology owner, TEK-KOL, a 50-50 partnership between SGI International of LaJolla, CA and SMC.

The plant will use the LFC Technology to process subbituminous Powder River Basin coal. Triton Coal Company's Buckskin Mine near Gillette, Wyoming is the host location and coal supplier. Two environmentally superior products are produced. The solid product, called Process Derived Fuel (PDF) is a stable, high-Btu fuel similar in composition and handling properties to eastern bituminous coals but very low in sulfur. Co-produced with PDF is a Coal Derived Liquid (CDL) that is similar in properties to a low sulfur number 6 fuel oil.

A substantial amount of pilot plant testing of the LFC process and laboratory testing of PDF and CDL was done by SGI and SMC. The pilot plant tests proved that the process was viable, predictable and controllable and could consistently produce PDF and CDL to desired specification. Laboratory testing, including PDF combustion tests, have yielded a wealth of information on both products. PDF does not exhibit spontaneous ignition tendencies, resorb moisture, or handle differently from its parent Buckskin coal. Ash properties are very comparable and combustion properties are excellent, even at relatively low residual volatility levels (<20%). CDL is different from petroleum derived oils due to its aromatic nature, but it should substitute directly for number 6 fuel oil according to the laboratory tests. It has a low viscosity at operating temperatures and is comparable in flash point, heat content and combustion properties. Low sulfur content, less that 1.2 pounds per million Btu, is the highlight of both products.

Feasibility studies, preliminary design, economics and some detailed design work was done by SMC in 1988. In June of 1988, an application was submitted to the Wyoming Department of Environmental Quality Air Quality Division for a permit to construct a 1000 ton per day LFC plant at Buckskin. This permit was approved in July, 1990. Work on the project was suspended in September, 1988 pending acquisition of risk sharing partners.

ENCOAL submitted a proposal to the DOE in August of 1989 as part of Round III of the Clean Coal Technology Program. The project was selected in December, 1989 and a Cooperative Agreement signed in September of 1990. A contract was awarded to The M.W. Kellogg Company for engineering, procurement and construction and they began their work about the same time. Ground breaking took place in October of 1990. By July of 1991, the basic design work was complete and construction was well underway.

Process Description

The LFC Technology uses a mild gasification process or mild pyrolysis as some know it. Figure 1 is a simplified flow diagram of ENCOAL's application of the LFC Technology. The process involves heating coal under carefully controlled conditions. Nominal 3" x 0" run-of-mine coal is conveyed from the existing Buckskin Mine to a storage silo. The coal from this silo is screened to remove oversize and undersize materials. The 2" x 1/8" sized coal is fed into a rotary grate dryer where it is heated by a hot gas stream. The residence time and temperature of the inlet gas have been selected to reduce the moisture content of the coal without initiating chemical changes. The solid bulk temperature is controlled so that no significant amounts of methane, carbon monoxide, or carbon dioxide are released from the coal.

The solids from the dryer are then fed to the pyrolyzer where the temperature is further raised to about 1,000 degrees F on another rotary grate by a hot recycle gas stream. The rate of heating of the solids and their residence time are carefully controlled, since these parameters affect the properties of both solid and liquid products. During processing in the pyrolyzer, all remaining free water is removed, and a chemical reaction occurs which results in the release of volatile gaseous material. Solids exiting the pyrolyzer are cooled to stop the pyrolysis reaction and transferred to a surge bin. Since the solids have no surface moisture and, therefore, are likely to be dusty, a dust suppressant is added as they leave the PDF product surge bin.

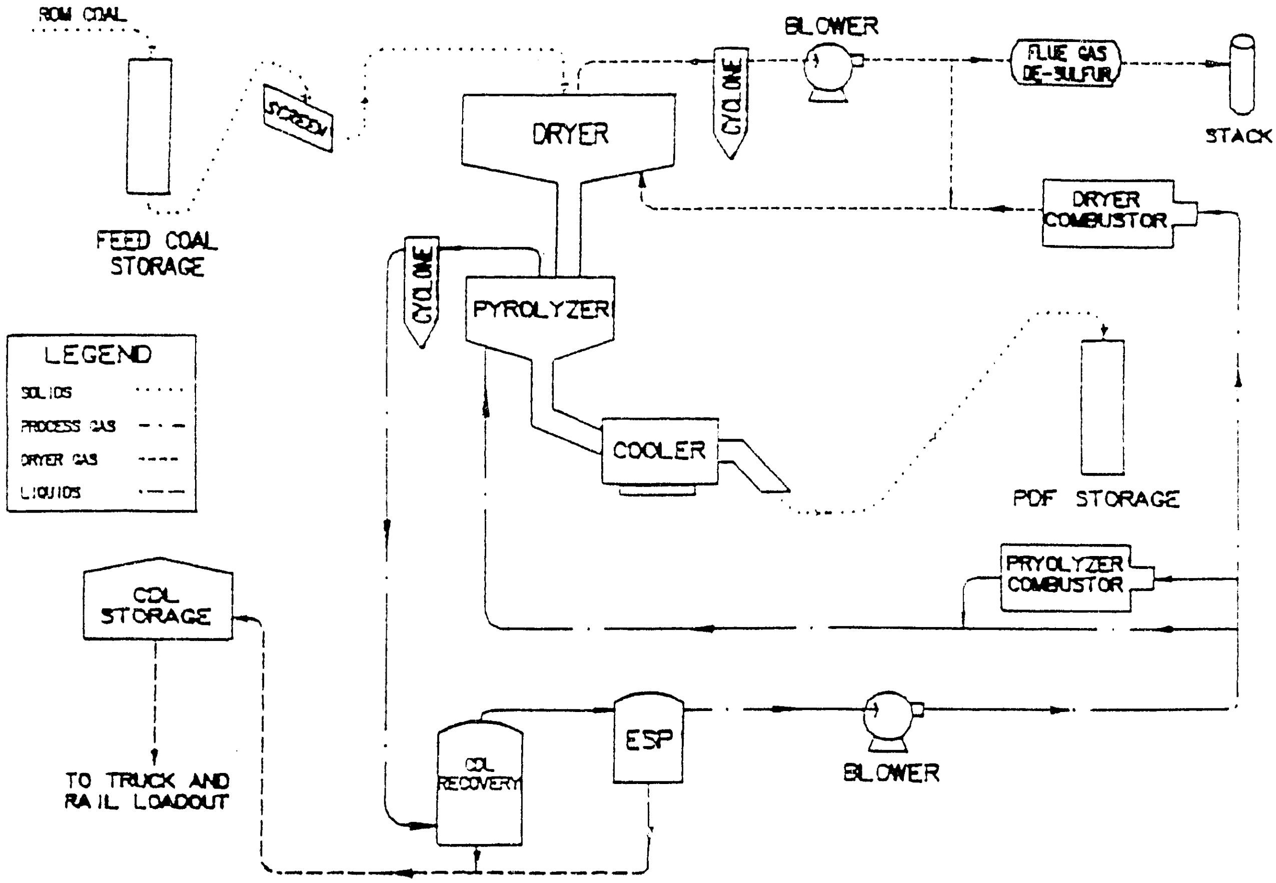

FIGURE 1. SIMPLIFIED FLOW DIAGRAM

The gas produced in the pyrolyzer is sent through a cyclone for removal of the particulates and then cooled to stop any additional pyrolysis reactions and to condense the desired liquids. Only the CDL is condensed in this step; the condensation of water is avoided.

Most of the residual gas from the condensation unit is recycled directly to the pyrolyzer, while some is first burned in the pyrolyzer combustor before being blended with the recycled gas to provide heat for the mild gasification reaction. The remaining gas is burned in the dryer combustor, which converts sulfur compounds to sulfur oxides (SOx). Nitrogen oxide emissions are controlled via appropriate design of the combustor. The hot flue gas from the dryer combustor is blended with the recycled gas from the dryer to provide the heat and gas flow necessary for drying.

The off-gas from the dryer is treated in a wet gas scrubber and a horizontal scrubber, both using a water-based sodium carbonate solution. The wet gas scrubber recovers the fine particulates that escape the dryer cyclone, and the horizontal scrubber removes most sulfur oxides from the flue gas. The treated gas is vented to a stack. The spent solution is discharged into a pond for evaporation.

The plant has several utility systems supporting its operation. These include nitrogen, steam, natural gas, compressed air, bulk sodium carbonate and a glycol/water heating and cooling system.

PROJECT DESCRIPTION

The ENCOAL project involves the design, construction and operation of a 1000 ton per day mild coal gasification demonstration plant and all required support facilities. A significant reduction in work scope and cost is being realized on the project due to the existence of the host Buckskin Mine. Coal storage and handling facilities, rail loadout, access roads, utilities, office, warehouse and shop facilities are all present at the Mine site and significantly reduced the need for new facilities for the ENCOAL project. Operations staff, supervision, administrative services and site security are being provided under a contract with Triton Coal Company. The balance of the project requirements are being provided by ENCOAL and its other subcontractors.

The project is divided into three phases as follows:

Phase I - Design and Permitting
Phase II - Construction and Start-Up
Phase III - Operation, Data Collection, and Reporting

Two budget periods encompass the work, the first covering Phases I and II and the second covering Phase III. A typical Work Breakdown Structure has been developed for the project.

Kellogg's scope of work included home office design, project coordination, field construction supervision, scheduling, project controls, procurement and project management. ENCOAL provided the technical support, field engineering and inspection. Kellogg and ENCOAL worked very closely during design and construction as an integrated team with each organization providing multi-skilled people, thus reducing total costs.

An important part of the engineering that was handled by ENCOAL in parallel with the Kellogg work was the PLC programming and process control systems design. A subsidiary of SGI, SG Tech, was contracted to assist in the application of their computer control technology to the ENCOAL project. Ultimately, it is anticipated that the plant process can be controlled and optimized using predictive feed forward and an adaptation of artificial intelligence methods.

ENCOAL and Triton handled the operations planning, training, maintenance planning, staffing, plant pre-commissioning and start-up, data gathering and initial plant operation. These activities took place in Phase II. Preparation of written plans and manuals was a part of these activities. All permitting requirements, and they were substantial, were handled by

ENCOAL. Phase III operation is now underway with Triton providing the operating and maintenance staff and ENCOAL providing the technical direction.

The ENCOAL project is demonstrating for the first time the integrated operation of several process steps:

a. Coal drying on a rotary grate using convective heating
b. Coal devolatilization on a rotary grate using convective heating
c. Hot particulate removal with cyclones
d. Integral solids cooling and deactivation-passivation
e. Combustors operating on low-Btu gas from internal streams
f. Solids stabilization for storage and shipment
g. Computer control and optimization of a mild coal gasification process

The product fuels are expected to be used economically in commercial boilers and furnaces and to significantly reduce sulfur emissions at industrial and utility facilities currently burning high sulfur bituminous fuels or fuel oils thereby reducing acid rain-causing pollutants.

RESULTS

Construction and Field Engineering

The design and construction of the ENCOAL demonstration plant was done on a fast track basis, that is, these activities were extensively overlapped. Figure 2 is an overall plot plan of the work site for convenient reference. Even though the design work had just started, field construction crews mobilized in early October, 1990. By the end of the year, all of the major underground foundations were done and the first silo was poured. Although activity slowed during the winter, by the spring of 1992, the feed coal and PDF silos had been completed. All underground piping and equipment foundations were also done.

The mechanical erection and instrumentation/electrical sub-contractors were mobilized in March and July of 1991 respectively. The first piece of major equipment, the PDF cooler, arrived in May, 1991. Structural steel began arriving in Late June, 1991 and was delivered on schedule from that point on, thus avoiding any delays in the building erection. Some of the major equipment was a different story, however. Blowers, pumps, combustors and some process vessels were slow to be requisitioned and even slower to be delivered by the vendors. Some delays in construction were then inevitable. In spite of these problems, construction went well by working around the missing pieces and by the end of 1991 most of the equipment was in place and the buildings were ready to be enclosed.

ENCOAL moved into its new offices in the fall of 1991 upon completion of the offsites buildings contract. Also included in this package was a pump house, motor control center and substation building. Above

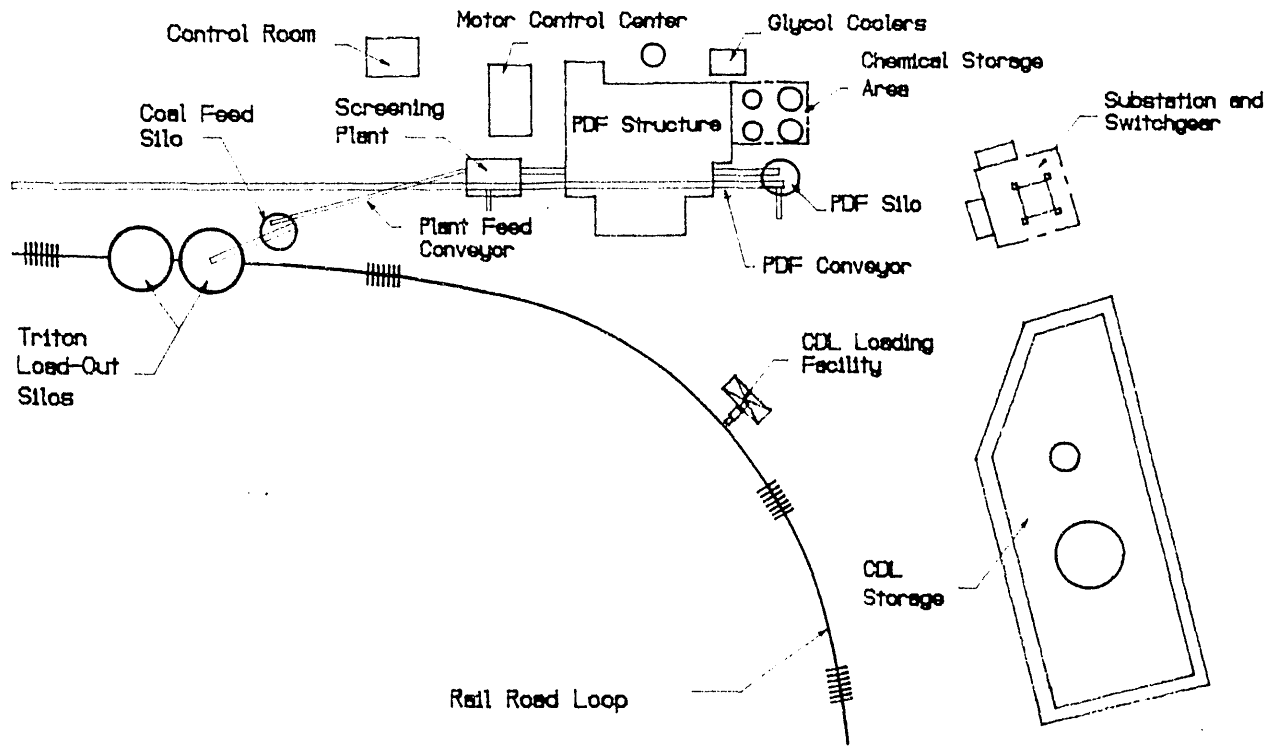

Figure 2. ENCOAL Project Plot Plan

ground piping, storage tanks and CDL loading facilities external to the process building were done under separate contracts and were complete by the end of 1991. Conveyors for the feed coal silo and into the plant were only partially done mainly because of misfits and because the building structures needed to be complete before final assembly. A significant amount of field engineering and retrofitting was required on these conveyors.

In February of 1992, the last piece of major equipment, the dryer cyclone, was set and the last of the structural steel put in place. Testing of piping systems had already begun on the lower floors. Turnover of major plant systems, a direct measure of completion, began in February and March. About this time, the conveyor and screening building misfits were corrected and final assembly accomplished. Pressure testing of all piping, except the large diameter ducts, was completed with few problems and turned over in mid March. Two of the plants blowers were used to test the large diameter ducts, some refractory lined, some internally clad and some coated, to 22 inches of water or four times operating pressure.

Numerous leaks were found and several cycles of fixing and testing were required before the final turnover and acceptance of the mechanical systems on April 17, 1992. Instrumentation and electrical turnover occurred on May 15 but many systems were in ENCOAL's control well before then. The 90% completion review with DOE was held April 7-9.

ENCOAL and Kellogg used the services of 22 subcontractors in the performance of the construction work. Total employment peaked at about 175 at one point, although more than 300 were present on site at various times. More than 320,000 manhours were required for this phase of the project. The cost for the first budget period which included design and construction was projected to be $51,200,000 and the project team held the costs to that figure through the use of a good controls plan and tight budget constraints.

Field engineering represented a significant effort on this project because of the fast track method used. Home office engineering was cut short without the normal level of detail engineering completed largely because vendor information was late in arriving and construction was underway. This added to the field engineering requirements. Field engineering also included environmental permitting. Revisions to the facilities and the process design subsequent to the issue of the original permits required modifications to those permits. The air permit, pond permits and additions to Triton's mining permits all had to be modified. Approval was secured on all of the required permits in a timely manner and did not affect construction. The only remaining permit item is the Wyoming Air Quality Division Permit To Operate which can only be issued after plant emissions testing. This is expected in the near future. ENCOAL's third and final HAZ-OP review was conducted the week of March 2 and all recommendations and questions were answered prior to putting heat in the plant.

One of the highlights of the construction effort was the excellent safety record achieved by ENCOAL, Kellogg and their sub-contractors. The lost time incident rate of 0.6, one in 320,000 manhours, was remarkable compared to the national average of 6.2. The MSHA recordables were one third of the national average at 4.6 per 200,000 manhours. This achievement was the result of a strong safety plan that incorporated both positive reinforcement and recognition with firm rules and discipline.

Commissioning and Start-up

As discussed, Triton Coal Company is operating the demonstration plant under a contract with ENCOAL. They have furnished a plant manager, plant engineer and 13 operating and maintenance personnel. Training of this staff, as well as ENCOAL's technical staff, took place from February 24 through April 10, 1992. The training consisted of prepared classroom sessions in the morning and hands-on maintenance and pre-commissioning activities in the afternoons. Teaching was done by ENCOAL's technical staff with help from consultants in some areas. Initial Commissioning Plans, Start-up and Shut-down Plans were also finalized during this time. Preventative maintenance plans, vessel entry procedures, safety and personnel protection procedures and operations plans were developed by the staff before, during and after the training period.

In the afternoon session, the operations staff worked very closely with Kellogg and their sub-contractors, doing some inspection as well as pre-commissioning. Pressure tests were witnessed, vessels were inspected before closing and piping was cleaned and flushed. This effort enabled systems commissioning to begin by the end of April, only two weeks after mechanical turnover. Systems commissioning took longer than expected, however, largely due to the incomplete nature of instrument electrical hookups. A number of pieces of equipment had to be repaired before they would work and leaks were discovered in the shells of the dryer and pyrolyzer during one of the pressure tests even though they did not show up before. In addition, a number of repairs had to be made to the seals and latch hardware on all of the five explosion relief doors. The result of all this work was a delay in the planned schedule of about a month before the plant was ready for coal.

Briefly, the planned sequence of events leading to full integrated operation of the plant can be summarized as follows:

1. Complete all loop checks and commissioning of individual systems.
2. Run both combustors and dry out refractory.
3. Operate complete dryer and pyrolyzer gas loops at operating temperatures.
4. Run coal through the plant cold and test all solids handling systems.
5. Run plant in integrated mode and make specification products for at least 24 hours.

The first two items were complete by May 12. Item three was done on May 23 following modifications to the combustors. Coal was first put in the plant on May 30 and on June 16 the first 24 hour run was completed where PDF and CDL were made. Since the first run, three additional hot coal runs have been made where close to specification products have been made. These runs have varied from 6 hours to 28 hours. However, it should be noted that the entire plant and all utilities run for much longer than the time coal is actually going in the unit due to the heat up and cool down times. The minimum run time is usually three days. The longest run so far was 6 days.

Plant Modifications

A great deal has been learned from the initial plant operations. Each run is followed by an evaluation of the data gathered by the plant's state of the art computer systems. A number of plant modifications and equipment repairs have resulted to correct the problems identified. These changes can be categorized into the following general areas:

1. Equipment repairs
2. Pump and blower capacities and pressures
3. Combustor controls
4. Dust collection
5. Process variables

Equipment Repairs. The most significant repairs to date have been to the pyrolyzer and dryer. During the third hot run, a diverter plate hooked the rotating grate due to heat expansion and improper adjustment and damaged several stainless steel beams. In both units, the seals between the inlet gas plenum and the discharge gas plenum required additional parts to keep them in place. These repairs required entry into both vessels and took more than three weeks.

Repairs have also been required on the seals on the primary gas blower in the dryer loop. These failed each of the first three times the plant operated and leaked CO and SO_2 into the building. A modified design was installed and worked fine on the last run. Other minor repairs have been made to the conveyor's like dribble collection, plug chute switches, access doors and idlers to improve reliability and spillage problems. There are no outstanding equipment problems at this time.

Pumps and Blowers. The problems in this area can be summed up as too big or too little. The combustor forced draft blowers have too much capacity and larger bypass valves had to be added to control air flow. The firewater pump put out too much pressure and had to be relieved. Pumps on the cooling water and process water systems turned out to be much too small since there is more water being circulated than expected. The supply pump has already been replaced and a new process water pump is being ordered. These items have not prevented the plant from running at design, but replacement will reduce manual operations and improve performance of the dust collection systems.

Combustor Controls. Heat for the dryer and pyrolyzer are provided by two sophisticated low Btu gas combustors. These combustors must also control emissions from the plant and therefore are critical parts of the overall process. The control systems for these units are highly cascaded and complex. In the runs to date these systems have demonstrated unacceptable swings in air to fuel ratios and heat output. A number of software and hardware corrections have been implemented on the dryer combustor and on the last hot run, it behaved very well. These same corrections have now been made on the pyrolyzer combustor.

Dust Collection. In all of the laboratory testing and pilot plant work that SGI and SMC did, PDF was a non-dusty product, especially when treated with SMC's proven dust inhibitor, MK. Indeed in the first four hot runs, the PDF was not dusty. However, during the transition period when run-of-mine coal is handled or when ramping up or down from operating temperatures, the coal is only partially processed. This partially processed coal is very dusty to the point where continued operation was not possible due to the hazards of escaping dust and the cleanup problems it created. A patented wet scrubber design was provided on the feed coal side of the plant because the feed coal was known to be very dusty. Since no significant amounts of dust were anticipated in the demonstration plant on the product side of the process, no dust collection provisions were made.

After fighting the problem in the first two runs, it was decided to add dust collection at the discharge of the PDF cooler and on top of the PDF silo. Wet scrubbers were obtained and installed for this application. It was also decided to remove the dryer fines collected in the dryer cyclone from the process and dispose of them with the scrubber effluent. In the last two runs, the dust problem was gone. Some minor problems with handling the slurry from the dust collection systems and from plant washdown still exist, but these do not affect the process.

Process Variables. A number of process variables are different under actual plant conditions than the theoretical plant design predicted. The most significant of these items is stopping the mild gasification reaction at the desired point. This is accomplished by solids quenching prior to the PDF cooler. If the mild gasification reaction is not stopped in the quenching step, heavy hydrocarbon vapors are released outside of the pyrolyzer loop where they are supposed to be collected. The result is a mess! Operating data has shown that the reactions take place for a longer period of time and at lower temperatures than predicted. In the last two runs, the quenching was adjusted as needed and the problems did not occur.

Heat loss in the ESP's and ductwork downstream of the CDL recovery column is much higher than predicted. This is because the actual surface area of the system is larger than the original design and it isn't insulated. The result is water condensation in the CDL product. Three inches of insulation is now being added to this system. Dust carryover in the pyrolyzer cyclone has also been occurring causing solids to be high in the CDL product. Low flow rates seem to be the cause. The dryer and pyrolyzer blowers have been the most reliable pieces of equipment in the plant and they are adequately sized to handle a wide variety of flows, so in future runs the mass flowrate in the gas loops will be increased to make the cyclone more efficient.

These are a sampling of the kinds of plant modifications that have been required so far. Many of the plant systems have operated very well as designed. Noise levels in the plant are much lower than was expected based on the vendor data on individual pieces of equipment. Temperatures in the building are manageable, although some additional vent fans are being evaluated. Most of the utilities have been very reliable and once the initial leaks were repaired, the ductwork and refractory linings are in good shape. Surely there will be more plant modifications to do, but, hopefully, the major ones are done.

Products. PDF and CDL have been made in each of the four hot coal runs that have been attempted so far. However, the first and third runs were of such short duration that the material produced during the transient conditions of start-up and shut-down could not be segregated from the good products. Tests on the products from these runs were erratic. For both of the longer runs, that is greater than 24 hours of more or less steady state operation, laboratory tests are believable. Table 1 gives the results of the test of the run-of-mine coal and PDF made from that coal for runs two and four. It appears that run two is slightly over pyrolyzed and run four is under pyrolyzed. The CDL made in these two runs is shown in Table 2. As discussed above, the Basic Sediment and Water (BS & W) is higher than projected for the CDL long term.

No data is yet available on the yield per ton of input coal, but based on the heat content of the plant make gas used as fuel in the combustors, more hydrocarbons are being generated than projected. A concern of many potential customers, the dustiness appears to be very well controlled by the MK and the removal of fines in the process. Stability of the PDF with respect to moisture resorption and spontaneous ignition is still not

Table 1. Product Analysis - Solids As Received

	Run-Of-Mine		PDF	
	Run 2	Run 4	Run 2	Run 4
Moisture	31.3	28.6	1.6	6.7
Ash %	5.3	5.3	10.1	8.3
Volatile %	29.6	32.1	N/A	22.4
Sulfur %	.40	.44	.74	.42
Btu/16	8416.	8416.	12,227.	11,754.
HGI	61	N/A	59	N/A

Table 2. Product Analysis - CDL

	Run 2		Run 4	
	A	B	A	B
API Gravity	3.0	6.9	3.1	4.5
Pour Point °F	92.	62.	75.	90.
Heat Value Btu/16	13,063.	16,767.	14,258.	16,634.
BS & W %	48.0	27.0	1.4	7.1
Flash Point °F	>140.	>140.	N/A	N/A
Sulfur %	.76	1.5	.30	N/A
Ash %	.24	.08	.07	N/A

Note: N/A means not available

well established. The size consist of the PDF product is considerably smaller than that obtained in any of the pilot plant operations. It is expected that the PDF product will continue to be small, but this will help the bulk density and it has been shown to be acceptable from a dust perspective.

FUTURE WORK

In the next year, ENCOAL plans to operate the demonstration plant at full capacity producing PDF and CDL for test burns. It is possible that sometime during this period, some coal will be run through the plant from sources other than the Buckskin Mine. The plant facilities will also be thoroughly tested during this time so that the capability of each piece of equipment as well as the total plant is known. There will also be a series of tests to vary process conditions and determine the affect on product qualities. In the near future, the plant emissions will be measured at operating conditions to verify permit compliance and pave the way for issuance of ENCOAL's Permit To Operate from the Wyoming DEQ.

Specifically, in the next few months, ENCOAL will deliver its first unit train of PDF product and the first tank cars of CDL. The computer control system that operates the plant will be put in the automatic mode for start-up, operation and shut-down. Data gathering on the process will be routine and done mostly by the computer system. Work on the design and economics for a large commercial plant will begin as soon as the demonstration plant is operating normally. The goal is to have at least one contract for a commercial plant within two years.

ENCOAL will also continue to abide by the Cooperative Agreement. The public design report will be finalized by December 1992. Topical reports and monthly and quarterly reports will continue to be produced on time. Patent disclosures will be submitted to the DOE and to the patent office as appropriate. In one year, an operations review will be held and informal reviews will be held approximately quarterly. At least two additional contracts for PDF for test burns should also be obtained.

END

DATE FILMED

2/5/93